National Aeronautics and Space Administration

WASHINGTON 25, D. C.

FIFTH SEMIANNUAL REPORT TO CONGRESS

NASA

OCTOBER 1, 1960 THROUGH JUNE 30, 1961

TO THE CONGRESS OF THE UNITED STATES:

Pursuant to the provisions of the National Aeronautics and Space Act of 1958, as amended, I transmit herewith a report on the activities and accomplishments of the National Aeronautics and Space Administration for the period of October 1, 1960, through June 30, 1961. This is the fifth of these reports since the passage of the legislation establishing that Agency, and supplements, in more detail, my annual report of January 31, 1962, which covered some of the same time period and reported on all agencies with responsibilities in the national effort in aeronautics and space.

Since the period covered by this report, the National Aeronautics and Space Administration, in cooperation with other agencies of the Government, has made substantial strides toward meeting our new and more ambitious aeronautics and space goals. This noteworthy progress, supported by the Congress, contributed to American leadership in many significant aspects in space accomplishments and has laid substantial foundation for greater successes in the future.

JOHN F. KENNEDY.

THE WHITE HOUSE,
July 11, 1962.

National Aeronautics and Space Administration

WASHINGTON 25, D.C.

FIFTH SEMIANNUAL REPORT TO CONGRESS

OCTOBER 1, 1960 THROUGH JUNE 30, 1961

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ADMINISTRATOR'S LETTER OF TRANSMITTAL

MAY 28, 1962.

THE PRESIDENT,
The White House.

DEAR MR. PRESIDENT: This Fifth Semi-Annual Report of the National Aeronautics and Space Administration, covering the period October 1, 1960, through June 30, 1961, is submitted to you for transmittal to the Congress in accordance with Section 206(a) of the National Aeronautics and Space Act of 1958.

The report period witnessed continued progress in NASA's research, development, and operational programs. In carrying out its assignments, NASA has utilized the services of its own personnel as well as those of other Government agencies, private industry, educational institutions, and the scientific community. It is worth noting, too, that since the period covered by this report, the amount of each NASA dollar spent with industry, universities, and other privately funded organizations has risen from 80 to 92 cents. Details of this and such other NASA activities as the first U.S. manned suborbital flight, the TIROS II meteorological satellite, the Explorer scientific satellites, and the successful tests of the X-15 research aircraft are reported in the chapters that follow.

The mounting accomplishments of the United States in space are something of which all Americans can be proud. Further, the value of our space activities is already being realized at home and abroad. For example, our weather satellites are providing valuable advance information on storms, and our communications satellite research holds forth the promise of less costly and more efficient communication between continents.

Through the data from flights of Astronauts Shepard, Grissom, Glenn, and Carpenter, we are learning how well a man can pilot a spacecraft, how he can adjust to the weightlessness and other stresses of space, and what he can observe to add to the information recorded by electronic sensors.

Already many Americans have benefited from our space programs. Liquid oxygen—now produced in large volumes and at lower cost as a result of space program requirements—is used in open hearth furnaces for efficiency and better steel. Liquid nitrogen, available as a byproduct of the liquid oxygen manufacturing process, is used to freeze whole blood for storage.

It is clear that space research will add immeasurably to man's knowledge of science, technology, his own planet, the universe, and possibly of the origin of life itself. The United States is in the forefront in seeking, obtaining, and disseminating this knowledge.

Sincerely,

JAMES E. WEBB,
Administrator.

CONTENTS

CHAPTER 20—OTHER ACTIVITIES—Continued

APPENDIXES

ILLUSTRATIONS

TABLES

CHAPTER 1

Introduction

Summary of Progress

During the period of this report—October 1, 1960, through June 30, 1961—the National Aeronautics and Space Administration made substantial progress in its varied programs.

Most noteworthy was the first suborbital flight in Project Mercury, which took place on May 5, 1961. The importance of this achievement lies in the fact that it was a prerequisite to manned orbital flights.

Also during the report period, NASA launched TIROS II—the second in a series of weather satellites which will eventually provide worldwide observation of atmospheric phenomena. Televised photographs of cloud cover and other meteorological data transmitted by the TIROS satellites have proved valuable in scientific research and day-to-day weather forecasting. In fact, the weather satellite may be the most important development in the history of weather observation and forecasting.

Equally significant were the four successful Explorer scientific satellites launched by NASA during these months. The data they have transmitted on the ionosphere, on atmospheric density, on interplanetary magnetic fields and solar flares, and on cosmic radiation continue to shed light on many fundamental problems in basic scientific and space research. Late in the report period, new major national goals in space and new programs to achieve them were recommended by the President and endorsed by the Congress. NASA's long-range plan of space exploration was revised accordingly and now calls for a manned lunar landing before 1970. It also establishes earlier dates for the Project Apollo earth orbital and circumlunar missions. Project Apollo will spearhead NASA's manned space flight program for the 1960–70 decade.

The National Aeronautics and Space Act of 1958 calls upon NASA to exploit the earth's atmosphere and space "for the benefit of all mankind." For this purpose, the Agency has been stepping up its relationships with appropriate agencies of other nations through cooperative scientific experiments and the exchange of scientific data and personnel.

NASA also has increased its cooperative space activities within the U. S. Government. Examples are the SNAP–8 project and Project ROVER, joint NASA-Atomic Energy Commission endeavors. Similarly, NASA's relationships with private industry, educational institutions, and research organizations are being substantially broadened.

An intensive program was begun in 1960 to recruit needed additional skilled manpower. During the report period, 984 scientific and engineering personnel were added, as total full-time personnel rose from 15,603 to 16,995.

Shortly after taking office, the President nominated James E. Webb to be NASA Administrator. The Senate confirmed the nomination on February 9, and Mr. Webb was sworn in on February 14, 1961.

Some highlights of NASA activities follow:

... *October 21, 1960*—The seven Project Mercury astronauts completed their third centrifuge training program at the Naval Aviation Medical Acceleration Laboratory, Johnsville, Pa. Simulated Mercury Redstone suborbital flight conditions subjected the astronauts to the highest acceleration load (16 g's) expected in a Mercury flight.

... *November 3, 1960*—Explorer VIII was launched into an elliptical orbit by a Juno II booster. The Explorer satellite carried instruments to gather data on charged particles and micrometeoroids in the ionosphere.

... *November 15, 1960*—X–15 No. 2, with a new 57,000-pound-thrust XLR–99 engine, made its first test flight. It was piloted by Scott Crossfield.

... *November 22, 1960*—On the second test flight of X–15 No. 2 with the XLR engine, Test Pilot Crossfield restarted the engine in flight for the first time.

... *November 23, 1960*—The TIROS II experimental weather satellite was launched at Cape Canaveral, Fla.

... *December 6, 1960*—During the third X–15 No. 2 test flight, the engine was stopped and restarted twice.

... *December 9, 1960*—NASA research pilot Neil Armstrong made the first test flight of the X–15 No. 1, equipped with a new sensor nose device.

... *January 3, 1961*—NASA's Space Task Group, Langley Field, Va., which is responsible for Project Mercury and other manned space flight programs, was made a separate field element reporting directly to the Director of Space Flight Programs at NASA Headquarters.

... *January 24, 1961*—NASA announced specifications for its active communications satellite—Project Relay—and asked industries to submit bid proposals.

...*January 31, 1961*—A fully equipped operational Mercury capsule containing a chimpanzee made a 16-minute suborbital flight 421 miles down the Atlantic Missile Range. On this Mercury Redstone (MR-2) flight, the capsule's systems functioned well and the test animal survived in good condition.

...*February 10, 1961*—NASA "bounced" a telephone message from Washington, D.C., to Woomera, Australia, via the moon. NASA's Goldstone, Calif., tracking station sent the signals to the moon; the newly completed Deep-Space Tracking Station at Woomera, Australia, 8,000 miles from Goldstone, picked up the reflected signals. This was the first "moon bounce" transmission between such widely separated points.

...*February 16, 1961*—Explorer IX, a 12-foot balloon satellite to measure atmospheric density, was launched by a Scout rocket from Wallops Station, Va. Lost at first because its radiobeacon was not transmitting, it was later sighted and tracked by cameras and telescopes.

...*February 21, 1961*—An unmanned Mercury spacecraft boosted by an Atlas launch vehicle made a successful 1,425-mile flight down the Atlantic Missile Range from Cape Canaveral. The spacecraft, which reached an altitude of 107 miles and a velocity of 12,850 m.p.h., was recovered by a helicopter.

...*February 21, 1961*—Astronauts John Glenn, Virgil Grissom, and Alan Shepard were selected as members of the pilot team for the first Project Mercury flights.

...*March 7, 1961*—Maj. Robert M. White, USAF, piloted X-15 No. 2 to a speed record of 2,905 m.p.h.

...*March 10, 1961*—The Jet Propulsion Laboratory, Pasadena, Calif., picked up radio signals reflected by Venus. The signals, transmitted by JPL's Goldstone Tracking Station, came in strong and clear after a 6½-minute, 70-million-mile round trip. This transmission began a 2-month study of Venus.

...*March 16, 1961*—Goddard Space Flight Center, Greenbelt, Md., was dedicated.

...*March 24, 1961*—A Redstone launch vehicle carried a Mercury capsule to an altitude of 115 miles in a ballistic test flight at the Atlantic Missile Range. This mission qualified the Redstone for manned suborbital flights.

...*March 25, 1961*—Explorer X, a 78-pound probe to collect information on magnetic fields and interplanetary gases, was successfully launched from Cape Canaveral.

...*March 30, 1961*—The X-15 No. 2, piloted by NASA Research Pilot Joseph A. Walker, reached a record altitude of 169,600 feet (32.12 miles).

...*April 6, 1961*—In ground tests, a thrust chamber of the 1.5-million-pound-thrust F–1 engine produced a record thrust of 1,640,000 pounds for 13 seconds.

...*April 21, 1961*—Maj. Robert M. White, USAF, flew the X–15 No. 2 at 3,074 m.p.h. (Mach 4.6).

...*April 27, 1961*—Explorer XI, the world's first astronomical observatory satellite, was placed in orbit to detect and help determine sources of gamma rays.

...*May 1, 1961*—The Goddard Institute for Space Studies began operations in New York City. A branch of the Theoretical Division of the Goddard Space Flight Center, the Institute conducts theoretical research related to NASA space science programs. It is directed by Dr. Robert Jastrow.

...*May 5, 1961*—The first manned suborbital flight in the Mercury-Redstone (MR–3) was made by NASA Astronaut Alan B. Shepard.

...*May 23, 1961*—TIROS II completed 6 months in orbit. It transmitted useful meteorological information, including 31,485 television pictures, during the period.

...*May 25, 1961*—NASA Research Pilot Walker flew the X–15 No. 2 to a speed of 3,307 m.p.h. (Mach 5.0).

...*June 7, 1961*—NASA and the AEC announced plans to negotiate a contract for design and development of the NERVA nuclear rocket engine with an industrial team consisting of Aerojet-General Corp. and Westinghouse Electric Corp. NERVA is part of Project ROVER, a joint NASA–AEC program for development of a nuclear rocket propulsion system.

...*June 23, 1961*—Maj. Robert M. White, USAF, flew the X–15 at 3,603 m.p.h. (Mach 5.3), or 1 mile a second.

...*June 28, 1961*—NASA, the Department of Defense, and the Federal Aviation Agency jointly urged development of a supersonic jet transport capable of cruising at Mach 3 (2,000 m.p.h.).

CHAPTER 2

Manned Space Flight

Projects Mercury and Apollo

Astronaut Alan B. Shepard, Jr.'s successful suborbital flight on May 5, 1961, climaxed 9 months of steady progress in Project Mercury, first phase of the manned space flight program.

Meanwhile, beyond Mercury, NASA plans were proceeding for more advanced space missions, starting with Project Apollo; this manned lunar exploration program has been accelerated as a result of the President's May 25, 1961, decision to land a crew on the moon by 1970 and his recommended increases in the Agency's 1962 budget request.

Project Apollo is a major step toward manned exploration of the solar system. The lunar program will provide the Agency with the experience for subsequent flights to the nearer planets. The planetary missions, in turn, will have as their scientific objectives the study of the origin and evolution of the solar system, the study of the nature of planetary surfaces and atmospheres, and the search for life forms.

Need for Manned Space Flight

Scientists have explained why man rather than instrumentation alone is setting out to explore the moon and the regions beyond as follows:

Man's integration with a vehicle system greatly enhances its reliability. Besides performing pilot, navigator, and flight engineering functions, man can make in-flight tests and repairs. (The X–15 rocket-powered research airplane program is a striking example. At least one-fifth of the test flights to date would have failed without a pilot in the cockpit to correct malfunctions of equipment, instruments, and powerplant. In many cases, the X–15 pilot brought back valuable flight data that would have been lost in an unmanned craft because of telemetry or instrument failure.) Similarly, in space exploration, man's ability to observe, to reason, and to take action cannot be reproduced by instruments.

Project Mercury Advances

Work on Project Mercury at Cape Canaveral and at the plant of the capsule contractor, McDonnell Aircraft Co., St. Louis, Mo., went ahead on a three-shift, 7-day-week basis in preparation for the first manned orbital flight. The developmental flight test program had begun on September 9, 1959, with the first of a succession of unmanned flights using Little Joe, Redstone, and modified Atlas D launch vehicles to test capsule performance and operational techniques.

Nine unmanned flight tests and one manned suborbital flight test of the Mercury spacecraft were conducted during the report period. These tests—in the main highly successful—helped pave the way for the first manned orbital flight. Detailed accounts of the tests follow in chronological order:

Little Joe 5 Test

In what was to have been a test of the capsule escape system under maximum aerodynamic pressures, a solid-fuel Little Joe launch vehicle fired a Mercury production capsule from Wallops Station, Va., November 8, 1960. Because of a faulty switch assembly, the escape rocket fired prematurely during the launch phase; as a result, the capsule clamp ring did not release, and the capsule did not separate from the booster.

The escape tower, capsule, and launch vehicle combination followed a ballistic trajectory and landed 13 miles offshore. The capsule and parts of the launch vehicle were recovered from the ocean floor at a depth of 70 feet.

First Mercury-Redstone Launch Attempt

The first Mercury-Redstone (MR–1) launch attempt took place on November 21, 1960, at Cape Canaveral. However, the Redstone engine cut off moments after ignition, when the vehicle had lifted scarcely a fraction of an inch off the pad. As a result, the Mercury escape tower received the signal for normal engine burnout, which should not have occurred until 140 seconds after lift-off. The escape tower's rocket fired, carrying the tower away from the capsule just as it would have after normal launch vehicle shutdown. The tower was carried to an altitude of about 4,000 feet, leaving the capsule still joined to the Redstone, and landed 1,200 feet northwest of the launch pad. The Redstone suffered minor damage when it settled back on the pad.

Later examination disclosed that an electrical cable from the launching platform to the launch vehicle disconnected about 20 milliseconds too soon because of a faulty circuit. The circuit was modified to prevent recurrence.

Second MR–1 Test Succeeds

After a few components were replaced, the same capsule used in the previous attempt was launched on December 19 by a Redstone vehicle. After a 16-minute flight at speeds up to 4,300 m.p.h., the capsule was recovered by a helicopter from the Atlantic Ocean off Grand Bahama Island. The capsule traveled 240 miles, reached an altitude of 135 miles, and landed within 8 miles of the programed impact area, with all systems performing satisfactorily.

Purpose of the flight: to qualify the capsule and Redstone combination on a short-range ballistic flight preparatory to manned flight. The seven Mercury astronauts—two of them in an F–106 Delta Dart chase plane—witnessed the launch.

During the 140-second boost phase, gravity forces built up to 6 g's and velocity to 4,300 m.p.h. At Redstone burnout, the 16-foot escape tower was jettisoned, and the capsule separated 10 seconds later. Automatic stabilization and control system jets steadied the capsule and 5 seconds after separation turned it 180° so that the beryllium heat shield faced forward.

After coasting to an altitude of 135 miles, the capsule was oriented for retrorocket ignition by its reaction control jets. Following retrorocket firing, the capsule was oriented by its stabilization and control system in a heat-shield-down position. It fell to an altitude of 21,000 feet, where the parachute sequence began. The capsule was spotted by the recovery helicopter when it reached 5,000 feet.

MR–2 Carries Test Animal

On January 31, 1961, a Redstone (MR–2) fired from Cape Canaveral a fully equipped, operational Mercury capsule on a 16-minute suborbital flight. The capsule contained test animal No. 65—a 37½-pound chimpanzee named "Ham" (for *H*olloman *A*ero*m*edical Laboratories, Holloman Air Force Base, N. Mex., where he was trained). Forty-three months old and 3 feet tall, Ham had been selected from a colony of six chimpanzees taught to perform simple manual tasks during space flight tests.

A booster malfunction sped the capsule considerably farther, faster, and higher than planned, but the spacecraft's systems functioned well and the test animal survived the flight in good condition.

At lift-off, the Redstone's thrust regulator "overthrottled," and more thrust was produced than had been programed. The velocity integrator—which should have sensed the overspeed—was not activated soon enough. Consequently, the booster burned out 5 seconds prematurely at 137 seconds and at a higher speed than expected. This burnout triggered the automatic abort sequence, separating the capsule from the rocket. The flight plan called for: (1) a capsule speed of 4,200 m.p.h.; (2) an altitude of 115 miles; (3) a range of 290 miles; and (4) reentry acceleration forces of 12 g's. Actual flight maximums were: (1) 5,100 m.p.h.; (2) 156 miles; (3) 421 miles; and (4) 17 g's during escape-rocket firing and 14.6 g's on reentry.

The capsule abort sequence functioned well. The main parachute opened, as programed, at 10,000 feet and the capsule landed in the Atlantic, 225 miles northeast of Grand Bahama Island, 100 miles from the nearest surface recovery ships. The capsule remained upright for 2½ hours, until the heavy seas toppled it on its side. Wave action had worn the straps which connect the heat shield to the capsule. The heat shield, which normally serves—with the impact bag—as a sea anchor, sank.

Three hours after lift-off, a helicopter retrieved the capsule from the water and, 46 minutes later, lowered it to the deck of the landing-ship dock (LSD) *Donner.*

Secured in a sealed, pressurized flight couch, the chimpanzee suffered no ill effects from the flight. Telemetry records revealed that even during maximum-g and through 6½ minutes of weightlessness, Ham performed shock-avoidance and light-recognition lever-pushing tasks, as he had been trained.

MA-2 Flight Highly Successful

Project Mercury passed an important milestone on February 21, when the Mercury-Atlas combination functioned smoothly during a severe test at Cape Canaveral. The successful flight was an essential step before manned orbital flights could be attempted.

The purpose of this test was to shut down the Atlas prematurely and simulate an abort. Then the capsule would enter the atmosphere steeply, and encounter maximum airloads and heating rates.

Powered flight was normal; after separation, the capsule coasted to an altitude of 107 miles where its automatic stabilization and control system oriented it for a steep entry. The capsule landed 1,425 miles downrange in the Atlantic about 18 minutes after lift-off, attaining a maximum velocity of 12,850 m.p.h. Maximum reentry deceleration was 16 g's.

A U.S. Navy search aircraft sighted the capsule 4 minutes after it landed; a Marine helicopter recovered it and deposited it on the deck of LSD *Donner* shortly afterward.

The capsule performed well under the severe entry temperatures. A few representative maximum temperatures sustained by the capsule: conical shingle, 1,200° F.; antenna canister, 1,500° F.; and inner skin of cabin, 140° F.

To reduce the stresses caused by aerodynamic turbulence downstream of the capsule payload (pressure disturbances which do not exist for the standard Atlas payload), the MA–2 booster was modified by the addition of an 8-inch-wide stainless steel band at the top of the liquid oxygen tank. The adapter was also strengthened with reinforcing rings.

Little Joe 6 Partial Success

A March 18 test of the capsule escape system and structure, under the maximum aerodynamic forces it would undergo in an abort during an Atlas launch, did not fulfill its objectives.

Twenty seconds after the Little Joe vehicle lifted off with the capsule from Wallops Station, Va., the escape sequencer malfunctioned, causing the escape rocket to fire 14 seconds prematurely.

Twenty-three seconds later, the capsule was separated and tumbled away from the booster. The tumbling deployed both main parachutes simultaneously, and the capsule landed in the Atlantic 18 miles southeast of Wallops. Despite the mishap, the capsule survived the 23-minute flight in sound condition. An unexpected bonus was the finding that the capsule could withstand the shock of parachute-opening pressures greater than its design limits.

Mercury Redstone Booster Qualified

After the Redstone malfunctions in the MR–2 flight, the thrust regulator and velocity integrator were modified to prevent recurrence of overspeeding. On March 24, the modified Redstone, carrying a boilerplate Mercury capsule, was launched from Cape Canaveral to an altitude of 115 miles and a downrange distance of 311 miles. (The test did not call for capsule separation and recovery.) The completely successful flight qualified the Redstone for manned suborbital flights.

Mercury-Atlas (MA–3) Aborted

An attempt to launch a Mercury capsule containing a mechanical astronaut-simulator on a one-orbit flight was aborted on April 25 at Cape Canaveral because of a faulty programer in the Atlas booster. The flight would have tested the capsule systems and the worldwide communications, tracking, and recovery networks.

Forty seconds after lift-off, the range safety officer sent a command signal cutting off fuel to the booster and starting the capsule abort sequence. After an automatic delay of 3 seconds, the booster was destroyed.

The abort maneuver, which took place at 14,000 feet, proceeded normally. The capsule coasted to a maximum altitude of 24,000 feet and landed 600 feet offshore. It was not damaged, and all systems functioned satisfactorily.

Little Joe 5B Succeeds

The capsule flown in the Little Joe 5 test on November 8, 1960, was recovered in good condition and reflown on April 28, 1961, from Wallops Station in another attempt to attain the original flight objectives—to test the capsule escape system.

The test was successful, but unexpectedly severe. One of the booster engines fired 5 seconds late, causing the booster to pitch over more rapidly than planned and to fly a low-altitude trajectory. The peak altitude of 14,000 feet was less than half the programed altitude. Because of the high density at this lower altitude, the aerodynamic pressures were approximately twice as great as planned. The capsule performed well and was recovered in excellent condition.

First Manned Suborbital Flight (MR–3)

The first manned suborbital flight in Project Mercury was carried out successfully on May 5, 1961.

At 9:34 a.m., e.s.t., a 78,000-pound-thrust Redstone lifted off from Pad 5 at Cape Canaveral, carrying astronaut Alan Bartlett Shepard, Jr., 37, in a Mercury spacecraft.

The 2,700-pound capsule landed 302 miles downrange in the Atlantic Ocean 15 minutes 22 seconds later, after reaching a peak altitude of 116½ miles and a top velocity of 5,180 m.p.h.

Astronaut Shepard underwent 5 minutes 4 seconds of weightlessness, and maximum reentry forces of 11 g's. He carried out all his tasks as assigned and suffered no adverse physiological effects from his flight.

The flight sequence:

. . . 1:05 a.m.—Shepard and his backup—fellow astronaut John H. Glenn, Jr.—are awakened in Hangar S quarters by Air Force Surgeon William K. Douglas. Shepard and Glenn eat low-residue breakfasts.

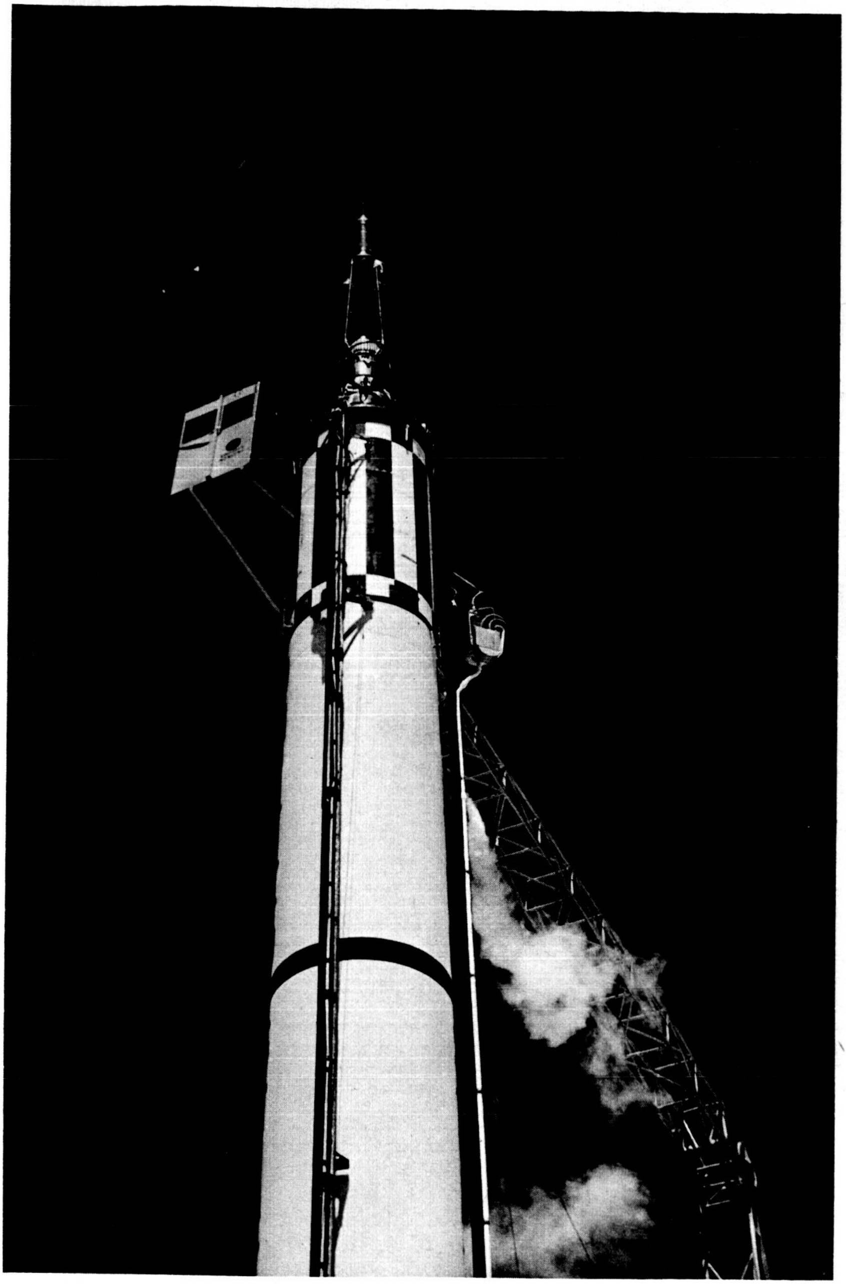
. . . 2:20 a.m.—Dr. Douglas completes physical examination of both men.

. . . 4:00 a.m.—Shepard, now completely dressed in a 30-pound aluminized nylon and rubber pressure suit, steps into medical van for ride to Pad 5.

. . . 5:15 a.m.—Shepard leaves van, rides up gantry elevator, and climbs into the capsule (named "Freedom 7") on top of the 69-foot launch vehicle.

. . . 6:10 a.m.—Capsule hatch is closed and sealed.

. . . 9:34 a.m.—Lift-off. During lift-off, Shepard reads instruments and reports all operations are normal. "This is Freedom 7, the fuel is go. 1.2 g, cabin at 14 p.s.i. (pounds per square inch), oxygen is go."



Close-up of the Mercury capsule. The "cherry picker" crane stands by to remove the pilot in case of trouble as the launch countdown nears its end

... T plus 2:22; Redstone engine shutdown. Automatic signal given to capsule to separate escape tower. Capsule separation occurs 10 seconds later.

... T plus 2:37; autopilot yaws capsule 180° so that heat shield faces forward.

... T plus 3:10; Shepard turns off automatic controls and assumes manual control—a task not known to have been previously performed in space. Shepard: "Switching to manual pitch."

... T plus 4:44; an automatic timer in capsule starts retrofire sequence; the capsule is reoriented to retrofire angle of 34° in pitch and 0° in yaw and roll.

... T plus 6:20; astronaut places capsule at atmosphere entry angle, 40° from the local horizontal.

... T plus 7:48; start of entry is indicated by 0.05 g light on capsule instrument panel.

... T plus 9:38; drogue parachute deploys at altitude of 21,000 feet.

... T plus 10:15; main 63-foot-diameter parachute deploys at 10,000 feet. Capsule descent now at rate of 30 feet per second. Sarah Beacon, a radio homing device, is activated.

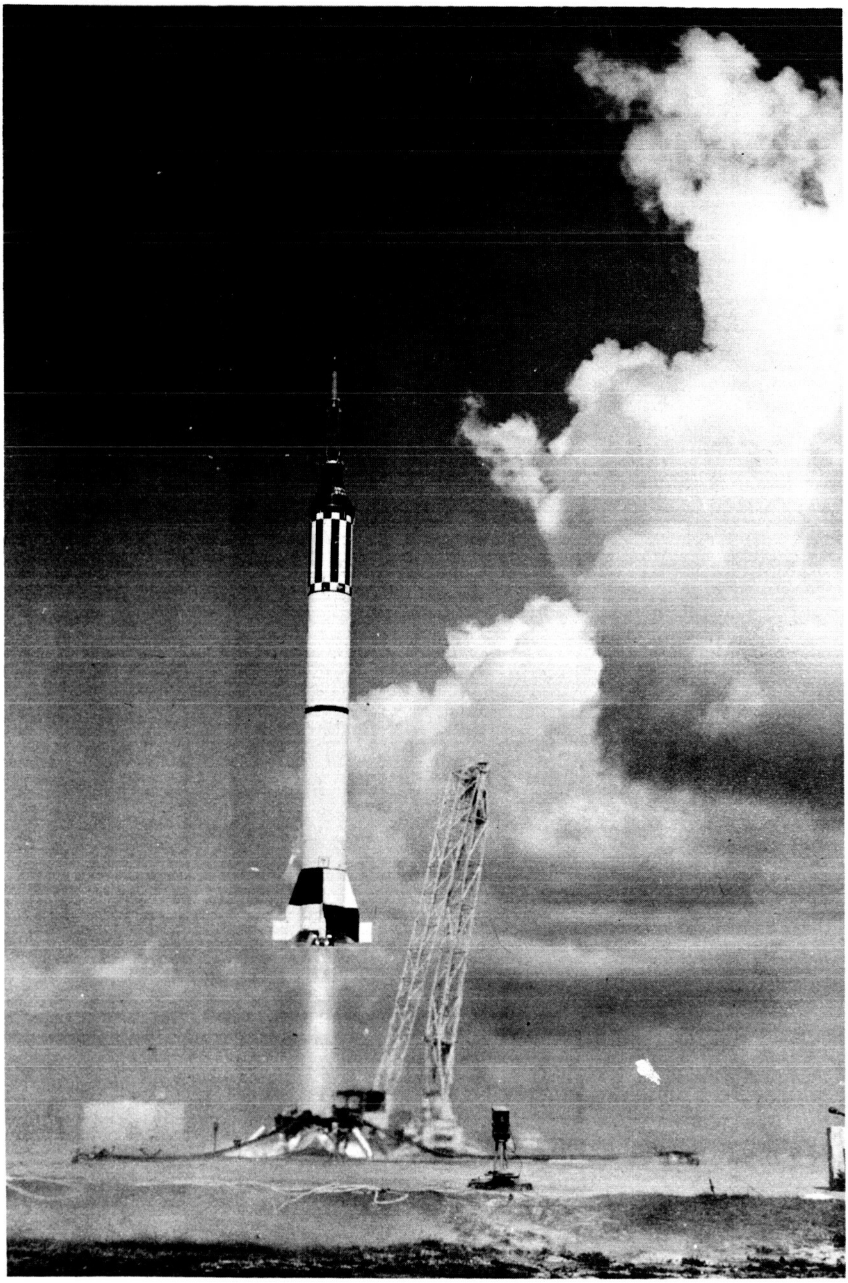
... T plus 15:22; landing. Astronaut begins recovery aid procedure—releases yellow-green dye marker and HF whip antenna.

Recovery Operation Smooth.—When the Redstone engines cut off, a message giving the impact point predicted by the computer was sent to the aircraft carrier U.S.S. *Lake Champlain* in the landing area northeast of Grand Bahama Island. This information enabled the pickup helicopter pilots to locate the capsule and follow it closely. A Marine Corps helicopter snared the lifting hook on top of Freedom 7 with a "shepherd's crook," a 12-foot aluminum pole with spring-locking hook, and pulled the capsule partially out of the water; the helicopter crew then dropped another line with a "horsecollar" harness to Shepard who had removed the hatch and was sitting in the hatch frame. He was hauled into the helicopter within 2 minutes of landing and was on board the carrier 3 miles away, after another 6 minutes.

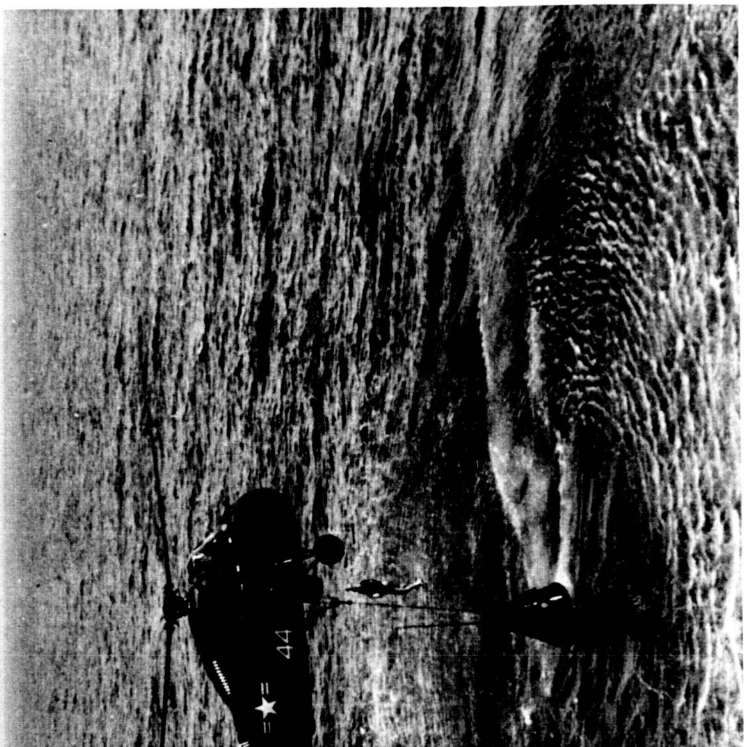
Six destroyers lay along the path of his flight, and ten search-and-chase aircraft were in the air.

Shepard Debriefed.—After a preliminary medical examination aboard the carrier, Shepard was flown to Grand Bahama for 2 days of combined medical and technical questioning.

The astronaut said he was very comfortable during the weightless period and that the water landing was no more severe than the shock a pilot receives when his airplane is catapulted from a carrier.



Mercury Redstone 3, carrying Astronaut Alan B. Shepard, is launched at Cape Canaveral, Fla., May 5, 1961



Astronaut Alan B. Shepard, Jr., and his Mercury spacecraft are lifted from the sea

Vibrations Encountered.—He said that the launch and entry accelerations were identical with those he had experienced many times on the human centrifuge at the U.S. Naval Air Development Center, Johnsville, Pa. He did, however, notice a mild vibration as the capsule sped through the transonic speed range during launch; the vibration continued through the maximum dynamic pressure region. Although his vision was somewhat blurred during this 10-second vibration period, he was able to read several critical capsule pressures on the instrument panel.

The vibrations, which were expected, were caused by aerodynamic turbulence downstream from the capsule-to-adapter clamp ring. Subsequent flights will incorporate special clamp ring fairings which should reduce the turbulence and the resultant vibrations.

Manual Controls Used.—The retrofire maneuver was accomplished by using the manual control system and observing the rate and attitude indicators. Shepard reported that the rocket thrust misalinement was small and that it caused relatively low angular disturbances on the capsule. He felt that the actual angular acceleration imparted to the capsule provided motion cues which made attitude control easier than in the fixed-base training simulators. He also felt that because more visual, acceleration, and audio cues were present during flight than in the simulators, he had positive assurance of events such as capsule separation, escape-tower jettison, retrofire, retropack jettison, and parachute deployment.

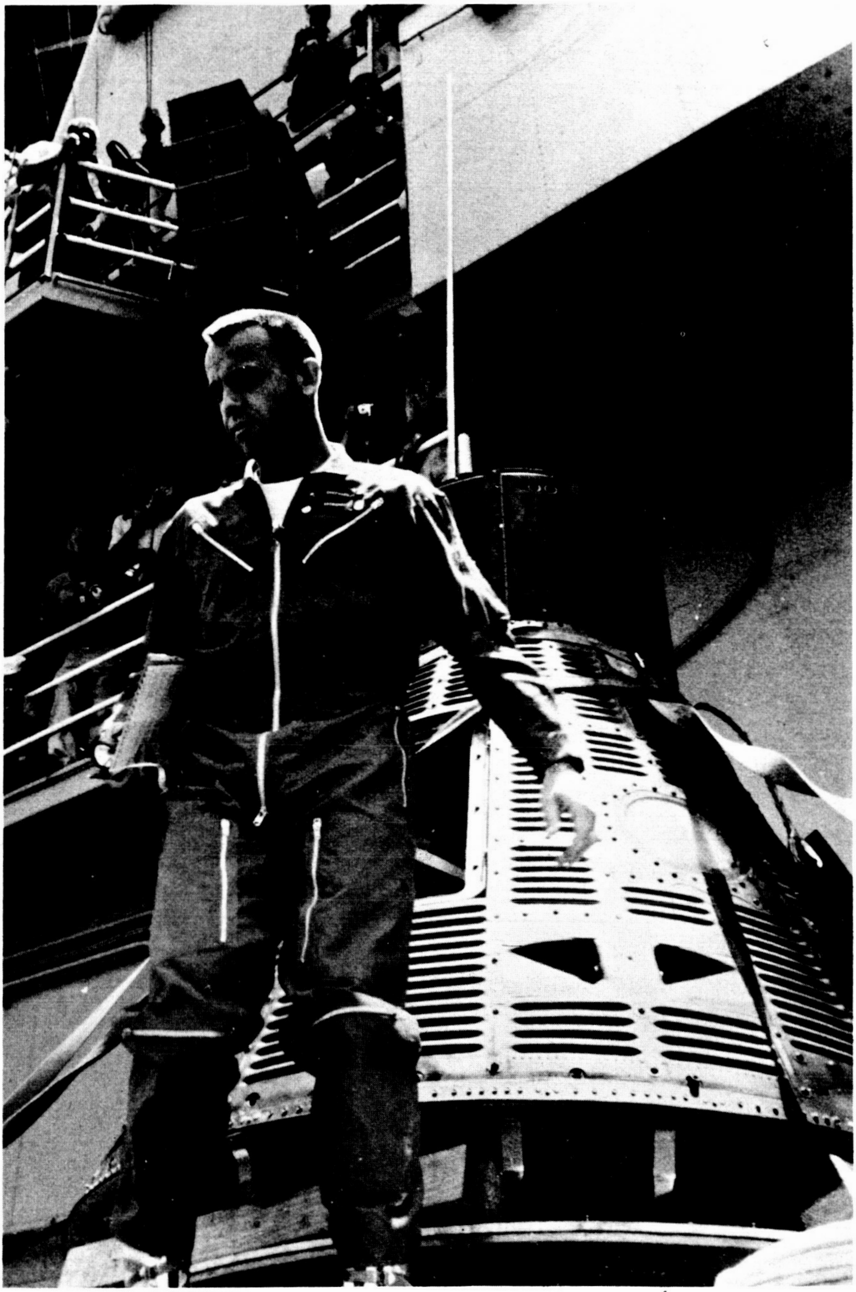
Physiological Observations.[1]—Physiologically, Shepard's performance was similar to that observed during the training sessions on the Johnsville centrifuge. His heart rate did not exceed 135, and his respiration rate was normal. Zero gravity caused no difficulty; the 5 minutes of weightlessness were hardly noticeable because his attention was occupied with capsule-control duties and visual observations through the periscope and windows.

Astronaut Training and Other Project Details

Three Astronauts Selected.—Several weeks before the first manned Mercury-Redstone flight, NASA chose three of the seven astronauts to begin contentrated training. They were Lt. Col. John H. Glenn, Jr., USMC; Capt. Virgil I. Grissom, USAF; and Comdr. Alan B. Shepard, Jr., USN.

In announcing the decision, Robert Gilruth, Director of Project Mercury, said: "Selection of the pilot team was based on an evaluation

[1] For complete technical and medical details of the test see Chapter 13, "*Life Science Programs*," and also: U.S. National Aeronautics and Space Administration in cooperation with National Institutes of Health and National Academy of Sciences. *Conference on Medical Results of the First U.S. Manned Suborbital Space Flight.* A compilation of the papers presented, Washington, D.C., June 6, 1961.



NASA Astronaut Alan B. Shepard, Jr., and his spacecraft after the first Project Mercury suborbital flight, May 5, 1961

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Awards to

Alan B. Shepard, Jr.

the

NASA DISTINGUISHED SERVICE MEDAL

For Outstanding Contributions to Space Technology

His flight as the first United States astronaut was an outstanding contribution to the advancement of human knowledge of space technology and a demonstration of man's capabilities in suborbital space flight.

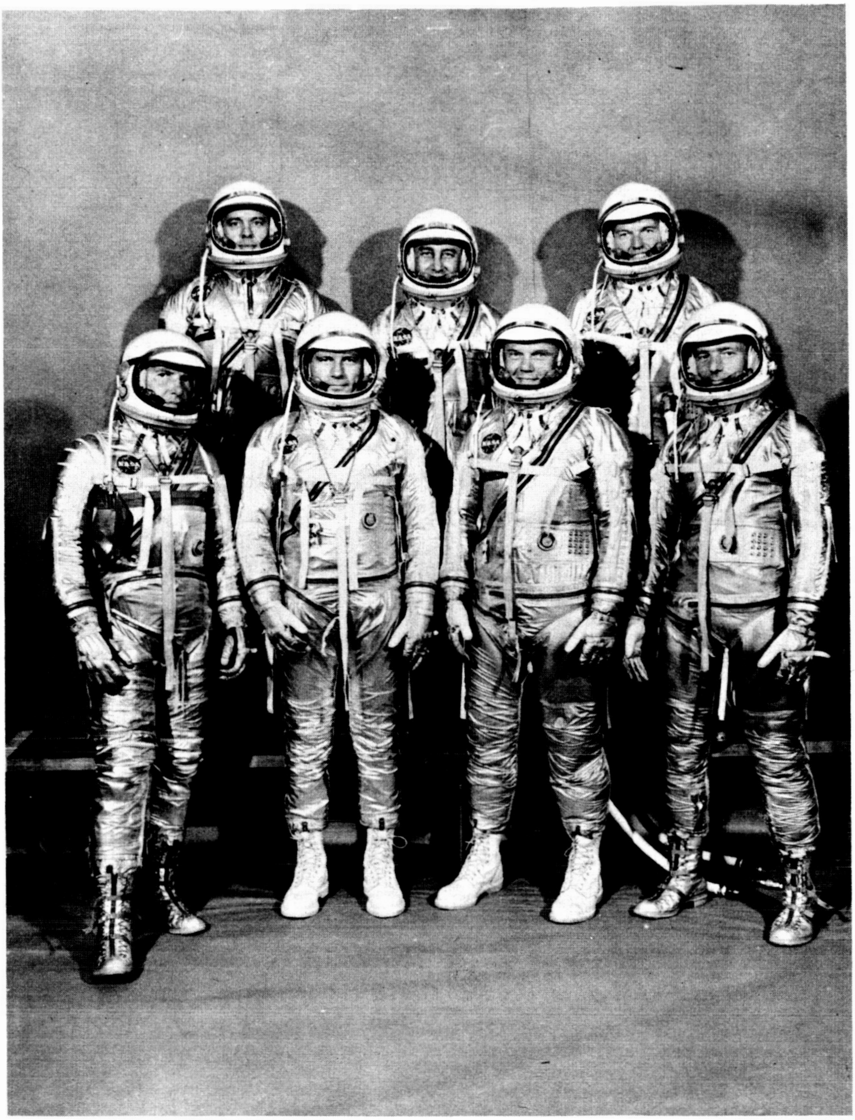
Signed and sealed at Washington, D.C.
this fifth day of May
Nineteen Hundred and Sixty One

James E. Webb
ADMINISTRATOR, NASA

Hugh L. Dryden
DEPUTY ADMINISTRATOR, NASA

of the large amount of medical and technical information accumulated during the initial pilot selection process and the 22-month training program. * * * I would like to emphasize that all seven of the Mercury pilots are eligible for selection for later ballistic and orbital flights. * * * All seven men will work as a team during actual flight operations, with the six remaining pilots manning technical support and communications positions."

Throughout the report period, the astronauts "flew" in centrifuges and other space flight simulators, continued their wide range of studies, and took part in the unmanned flight tests in supporting roles; i.e., they flew photographic "chase" planes or handled communications with the capsule.



The seven Mercury Astronauts: Front, left to right—Walter M. Schirra, Jr., Donald K. Slayton, John H. Glenn, Jr., and M. Scott Carpenter. Back, left to right—Alan B. Shepard, Jr., Virgil I. Grissom, and L. Gordon Cooper, Jr.

For the May 5 suborbital flight, Astronaut Glenn stood by as backup pilot, and the other astronauts occupied key posts throughout the test.

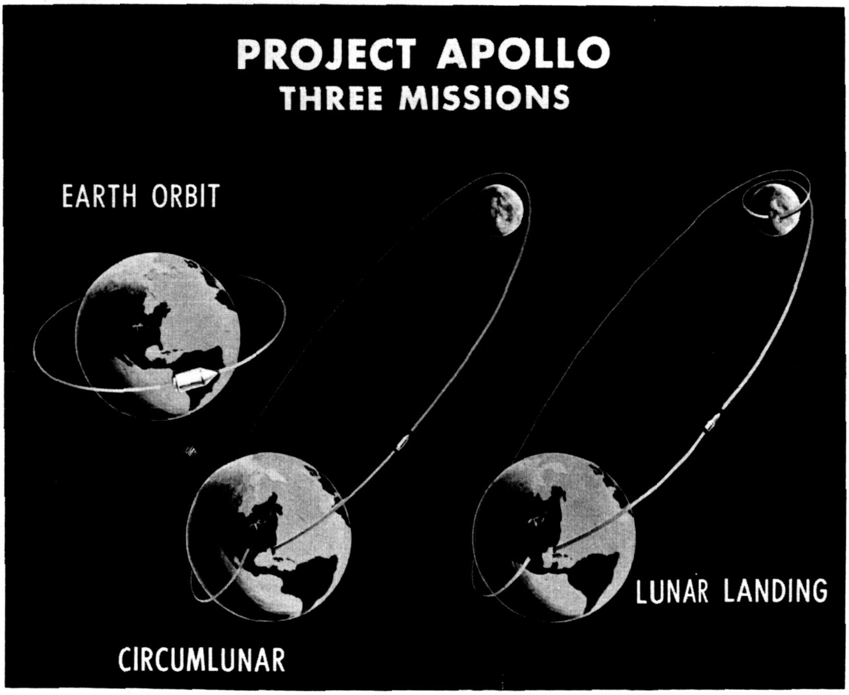
Mercury Weather Network Established.—On October 17, 1960, NASA and the U.S. Weather Bureau announced establishment of a Project Mercury weather-support group in the Bureau's Office of Meteorological Research. The group will forecast the winds, state of the sea, cloudiness, and visibility for all areas beneath the proposed orbit, with particular emphasis on the central Atlantic Ocean. The network headquarters is in Suitland, Md., adjoining the National Meteorological Center. The group also has units in Miami and Cape Canaveral.

Space Task Group Manages Project Mercury.—Responsibility for management of Project Mercury is as follows:

The NASA Space Task Group (STG) has overall systems management responsibility. STG drew up the Mercury capsule specifications upon which the contractor capsule proposals were made. (The capsule contract was awarded to McDonnell Aircraft Corp., St. Louis, Mo., on February 6, 1959.)

Tracking and communications network specifications were established by STG and the Langley Research Center. (The Western Electric Co. was selected as network contractor on July 13, 1959.) Capsule recovery is a joint NASA-Department of Defense effort.

Recovery Support.—The Defense Department recovery support for Project Mercury is under the direction of the commander of Destroyer Flotilla 4 at Norfolk, Va. The recovery forces include naval vessels, aircraft, helicopters, and amphibious rescue craft.



Mercury Medical Team Organized.—A team of 160 military and civilian medical specialists has been organized to serve with Project Mercury's recovery and tracking forces for the manned orbital flights. Most of these will stand by at hospitals near high- and low-probability landing areas, such as Cape Canaveral or Puerto Rico, to check the astronaut after flight. The balance will team with engineers at the 16 tracking and communications stations spotted under the orbital flight path to monitor the capsule systems and the astronaut's physical condition.

Contractor Delivered Capsules.—During the report period, seven new and two refurbished capsules were delivered to NASA by McDonnell Aircraft Corp. Many detailed, but no major, design changes were specified. However, the delivered capsules incorporated design changes initiated earlier in the program; for example, the No. 7 capsule used in Shepard's flight incorporated the impact-absorbing bag, but not the larger "picture window."

Project Apollo

Project Concepts Developed

The Mission.—Basic concepts for Project Apollo have been worked out in numerous NASA and NASA-sponsored studies. The ultimate objective of Project Apollo was described as the landing of three men on the moon. After exploring the lunar surface, the crew will launch their spacecraft and return to earth. This objective will be reached in progressive steps.

The Apollo spacecraft will first be flown in earth-orbit where its many components and systems will be well tested and evaluated in the space environment. These flights will also provide for crew training and the development of operational techniques. In conjunction with these qualification flights, the spacecraft can be used as an earth-orbiting laboratory for scientific measurements and technological studies.

Next, the spacecraft will be flown to greater and greater distances from the earth until manned circumlunar flight is achieved. In circumlunar flights, the crew will perform many of the guidance and control tasks that will later be required for the lunar landing mission, including return to earth, high-speed reentry, and earth landing.

Many Launch Vehicle Approaches Considered.—Fully as complex as the spacecraft is the development of reliable, workhorse launch vehicles and the gigantic launch pads with associated groundbased equipment. A number of launch vehicles and techniques are being considered for these missions. The two-stage Saturn C–1 will launch preliminary earth-orbital missions. The booster for the circumlunar mission had not been selected during this report period, but the giant Nova, still in the concept stage, may propel the manned spacecraft to lunar landing trajectories. Rendezvous techniques are also under study. NASA is developing the required large liquid engines, and large solid propellant motors are under U.S. Air Force study and development.

The Apollo Spacecraft Concept.—The Apollo spacecraft design has not yet been set but is likely to develop along the following lines:

To carry out its many missions Apollo will have to use the so-called modular concept. This concept uses various building blocks or modules of the vehicle systems for different phases of the mission.

The first component, the command center module, will house a three-man crew during the launch and reentry phases of the flight; it will also serve as a flight control center for the remainder of the mission.

The second unit is the service module. In earth-orbital flights it will return the craft to earth under both normal and emergency conditions. It will also be used for maneuvering in orbit and for orbital rendezvous with other satellites. For circumlunar flights, this same propulsion module will be able to return the spacecraft to earth safely from any point along the lunar trajectory. On circumlunar flights, it will provide midcourse and terminal guidance corrections; and it can place the spacecraft into a satellite orbit around the moon and eject it from that orbit and return it toward the earth. For the lunar landing mission, the same propulsion unit will be the takeoff stage from the moon to return the spacecraft toward the earth.

The third module is the propulsion stage that will decelerate the spacecraft as it approaches the moon and gently lower it to the moon's surface.

For the earth-orbital missions, a module can be added to serve as an earth-orbiting laboratory.

Of all the modules mentioned, only the command center will be designed to be able to reenter the earth's atmosphere and to be recovered on the surface of the earth.

Thus, the Apollo spacecraft is versatile, involving the development of a number of components but making maximum use of these components for three Apollo missions.

Major Problem Areas.—A vast range of problems is associated with development of Apollo spacecraft and the Saturn and Nova launch vehicles. A few examples follow:

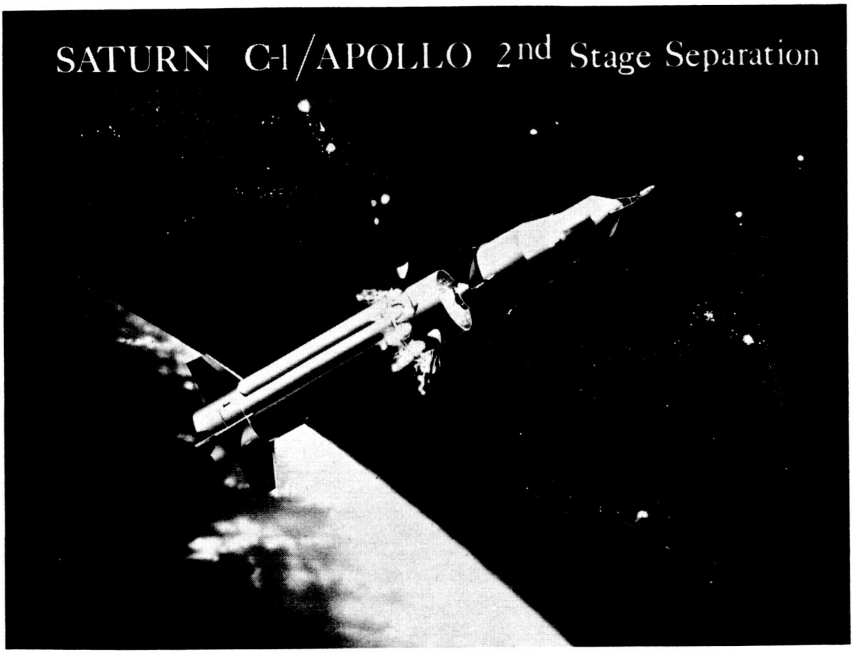
. . . During launch, the mission must be capable of being aborted at speeds up to burnout velocity of 25,000 m.p.h.

. . . Personnel safety must be assured in event of a booster explosion; provisions must also be made to protect the Apollo flight and launch crews from the great noise of multimillion-pound-thrust rocket engines.

... Booster guidance must accurately insert the spacecraft on a precisely determined trajectory to minimize corrections required during the mission.

... When it leaves the earth's atmosphere, the spacecraft will encounter various forms of radiation in the Van Allen zones and beyond. The shielding of the spacecraft and operational techniques to avoid the radiation are major problems involving numerous unknowns at the present time.

... A knowledge of the surface environment of the moon—its hardness and composition—must be obtained by unmanned exploration before Apollo's landing gear can be designed.



... Lift-off from the moon will require major launch operation advances. All equipment for the lunar takeoff must be prepared and checked out by the three-man crew. This number contrasts strongly with current launchings from Cape Canaveral which involve hundreds of people on the launch pad, in the blockhouse, and in the control centers, and indirectly involves thousands more at the checkout and tracking facilities. Furthermore, the propulsion and guidance systems for the lunar lift-off must be of the highest reliability if the spacecraft is to hit the proper trajectory for its earthward flight.

... Finally, when the spacecraft reaches the earth's atmosphere on the return trip, it will be traveling at more than 25,000 m.p.h.

Aerodynamic heating will be far more severe than at satellite speeds of 18,000 m.p.h. Also, the spacecraft must enter the earth's atmospheric fringe in a "flight corridor" that must be accurate to within about 40 to 60 miles. If the spacecraft fails to hit this narrow corridor—after a flight of a quarter million miles—it will encounter excessive deceleration or skip back out into space.

Three Feasibility Studies Completed.—Besides numerous NASA studies (whose substance has been outlined above) three feasibility design studies by manufacturers were submitted on May 15, 1961. The concurrent 6-month contracts of $250,000 each were with Convair Astronautics Division of General Dynamics Corp.; the General Electric Missile and Space Vehicle Department; and the Martin Co.

A major NASA-Industry Conference on Project Apollo was set for late July, and by mid-August NASA was scheduled to invite a number of companies to submit prime contractor proposals for the command center module of the Apollo spacecraft. At the same time, the companies were to be provided with copies of the feasibility studies and a detailed set of specifications. After bids in October 1961, NASA expects to decide upon a final design and award the prime contract by the end of the year.

Table I.—NASA Satellite and Probe Launchings, Oct. 1, 1960–June 30, 1961

Name, date, site, lifetime, mission	Launch vehicle	Payload	Test results
EXPLORER VIII (1960 Xi); Nov. 3, 1960 (10 years or more). *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* To investigate the ionosphere by direct measurement of positive ion and electron composition; gather data on the frequency, momentum and energy of micrometeorite impacts.	JUNO II. *Stages:* *1st:* Modified Army Jupiter. *2d:* 11 scaled-down solid Sergeant rockets in cluster. *3d:* 3 scaled-down Sergeants in cluster. *4th:* Single Sergeant rocket. *Gross lift-off weight:* 121,000 lb. *Height:* 76 ft. *Diameter at base:* 8¾ ft.	*Dimensions:* 30 in. high; 30 in. diameter. *Total payload weight:* 90.14 lb. *Instrumentation:* Includes: dipole antenna; single-grid ion trap; 4 multiple-grid ion traps; electric field meter; photomultiplier; micrometeorite microphone; 4 thermistors; sensor to measure electron temperature. *Transmitters:* 108 mc. at 70 mw. *Power supply:* Mercury batteries. *Transmitter lifetime:* 2–3 months; silenced Dec. 27, 1960.	Orbit achieved and all instrumentation functioning. *Period:* 112.7 minutes. *Orbital path:* Elliptical. *Launch inclination:* 49.9° to the Equator. *Velocities:* Perigee: 18,143 m.p.h. Apogee: 14,221 m.p.h. *Perigee:* 260 (miles). *Apogee:* 1,420 (miles).
TIROS II (Television and (1960 Pi) Infrared Observation Satellite); Nov. 23, 1960 (50–100 years in orbit). *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* To test experimental television techniques and infrared equipment leading to eventual worldwide meteorological information system.	DELTA. *Stages:* *1st:* Modified USAF Thor IRBM. *2d:* Liquid rocket modified from Vanguard with radio guidance. *3d:* Solid rocket modified from Vanguard with motor mounted on spin table. *Gross lift-off weight:* Approximately 112,000 lb. *Height:* 92 ft. *Diameter at base:* 8 ft.	*Dimensions:* 19 in. high; 42 in. diameter. *Total payload weight:* 280 lb. *Instrumentation:* Includes: 1 wide and 1 narrow-angle camera, each with tape recorder for remote operation; infrared sensors to map radiation in various spectral bands; attitude sensors; experimental magnetic orientation control. *Transmitters:* 5: 2 235 mc. at 2 watts; 1 237.8 mc. at 3 watts; 2 30 mw. tracking beacons at 108 mc. and 108.03 mc. *Power supply:* Nickel-cadmium batteries charged by solar cells. *Shell composition:* "Pillbox" shape covered on top and sides by 9260 solar cells. 5 pair of spin rockets and 4 transmitter antennas surround baseplate. Receiving antenna on top center. Aluminum/stainless steel shell.	Orbit achieved. Narrow-angle camera and IR instrumentation sending good data. Quality of wide-angle photos not good. *Period:* 98.3 minutes. *Orbital path:* Near circular. *Launch inclination:* 48.5° to the Equator. *Velocities:* Perigee: 16,941 m.p.h. Apogee: 16,691 m.p.h. *Perigee:* 388 (miles). *Apogee:* 452 (miles).

EXPLORER: Dec. 4, 1960. *Launched from:* Wallops Station, Va. *Mission:* To study performance, structural integrity, and environmental conditions of Scout research vehicle and guidance-controls system. And to inject inflatable sphere into earth orbit to determine density of atmosphere.	SCOUT. *Stages:* *1st:* Algol. *2d:* Castor—a modified Sergeant motor. *3d:* Antares—scaled up version of 4th stage. *4th:* Altair—modified X-248 Vanguard 3d stage. *Gross lift-off weight:* 36,100 lb. *Height:* 72 ft. *Diameter at base:* 40 in. This launching was the first orbital attempt by the United States using a solid-fuel rocket and the first orbital attempt with any vehicle from Wallops Station.	*Dimensions:* 12-ft. diameter. *Total payload weight:* 87 lb. *Instrumentation:* Radio beacon. *Transmitters:* One 2¼-lb., 3 by 4-in. radio-beacon transmitting on 136 mc. at 15 mw. First use of Minitrack frequency of 136 mc. in a satellite. *Power supply:* 280 solar cells and miniature storage batteries.	2d stage failed to ignite. Vehicle impacted in Atlantic about 80 miles from launch site.
PIONEER; Dec. 15, 1960. *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* To investigate environment between earth and moon and develop technology for controlling and maneuvering spacecraft from earth.	ATLAS-ABLE. *Stages:* *1st:* Modified AF Atlas "D" ICBM. *2d:* Liquid propellant adapted from earlier Able vehicles. *3d:* Solid-propellant adapter from earlier Able and Vanguard configurations. *Gross lift-off weight:* Over 260,000 lb. *Height:* 98 ft. (approximate).	*Dimensions:* 39-in. diameter sphere with four 24 by 24-in. paddlewheels. *Total payload weight:* 388 lb. *Instrumentation:* Included: Micrometeorite impact counter; high-energy radiation counter; instruments to measure total radiation flux and low-energy range of radiation spectrum; two magnetometers; sun scanner; scintillation spectrometer; plasma probe experiment; solid-state detector. *Transmitters:* 2 1.5-watt UHF transmitters operating at 378 mc. *Power supply:* Nickel-cadmium batteries charged by 8,800 solar cells.	Explosion destroyed vehicle about 70 seconds after launch at about 40,000 ft. Pieces impacted in Atlantic 8 to 12 miles from launch site.

Table 1.—NASA Satellite and Probe Launchings, Oct. 1, 1960–June 30, 1961—Continued

Name, date, site, lifetime, mission	Launch vehicle	Payload	Test results
EXPLORER IX (1961 Delta); Feb. 16, 1961 (several weeks to a year). *Launched from:* Wallops Station, Va. *Mission:* To study performance, structural integrity, and environmental conditions of Scout research vehicle and guidance-controls system, and to inject inflatable sphere into earth orbit to determine density of atmosphere.	SCOUT. Stages: *1st:* Algol. *2d:* Castor—a modified Sergeant motor. *3d:* Antares—scaled-up version of 4th stage. *4th:* Altair—modified X-248 Vanguard 3d stage. All solid propellant. *Gross lift-off weight:* Approximately 36,000 lb. *Height:* 72 ft. *Diameter at base:* 40 in.	*Dimensions:* 12-ft. diameter. *Total payload weight:* 80 lb. *Instrumentation:* Radiobeacon on balloon and in 4th stage. *Transmitters:* One 2¼-pound, 3 by 4-in. radiobeacon transmitting on 136 mc. at 15 mw. *Power supply:* 280 solar cells and miniature storage batteries on balloon.	Orbit achieved, Feb. 28, 1961; vehicle functioned as planned. Balloon and 4th-stage achieved orbit. Transmitter on balloon failed to function properly requiring optical tracking of balloon. *Period:* 118.3 minutes. *Orbital path:* Elliptical earth orbit. *Launch inclination:* 38 63° to the Equator. *Velocities:* Perigee: 17,866 m.p.h. Apogee: 13,976 m.p.h. *Perigee:* 395 (miles). *Apogee:* 1,605 (miles).
EXPLORER; Feb. 24, 1961. *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* To investigate shape of ionosphere by analysis of signals transmitted by the satellite on 6 frequencies using 14 channels of information.	JUNO II. Stages: *1st:* Modified Army Jupiter IRBM. *2d:* 11 solid-propellant motors. *3d:* 3 solid rockets. *4th:* Single solid rocket. *Gross lift-off weight:* 121,000 lb. *Height:* 76 ft. *Diameter at base:* 8¾ ft.	*Dimensions:* 30 in. diameter; 24 in. high. *Total payload weight:* 74 lb. *Instrumentation:* Transmitter; aspect sensor; 7 temperature sensors; 2 antennas. *Transmitters:* Single transmitter broadcasting on 6 frequencies at varying levels of power: 20.005; 40.010; 41.010; 108.02; 360.09; 960.24 mc. *Power supply:* Solar cells and nickel-cadmium batteries.	Malfunction shortly after booster separation resulted in loss of payload telemetry and failure of 3d and 4th stages to ignite. Orbit not achieved.

EXPLORER X (1961 Kappa); Mar. 25, 1961 (several weeks). *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* To gather definite information on earth and interplanetary magnetic fields and the way these fields affect and are affected by solar plasma.	THOR-DELTA. *Stages:* *1st:* Modified Thor. *2d:* Liquid rocket modified from Vanguard with radio guidance. *3d:* Solid rocket modified from Vanguard. *Height:* 92 ft. *Lift-off weight:* Approximately 112,000 lb. *Diameter at base:* 8 ft.	*Dimensions:* 52 in. high; antennae extend 85 in. *Total payload weight:* 78 lb. *Instrumentation:* Includes rubidium vapor magnetometer, 2 fluxgate magnetometers, a plasma probe, and an optical aspect sensor. *Transmitters:* 108 mc. operating at 35 percent efficiency and producing 5 to 6 watts of output power. *Power supply:* Chemical batteries. Battery-powered transmitter went dead after 60 hours.	Orbit achieved. Probe transmitted valuable information continuously for about 60 hours. Data received lent support to theory that interplanetary magnetic field near earth is mainly extension of magnetic field of sun. *Period:* 112 hours. *Orbital path:* Elliptical. *Launch inclination:* 33° to the Equator. *Velocity:* About 23,900 m.p.h. at 3-stage burnout. *Perigee:* 100 (miles). *Apogee:* 145,000 (miles).
MERCURY-ATLAS III (MA-3); Apr. 25, 1961. *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* To place an unmanned spacecraft in earth orbit to test means of returning it to earth within preplanned recovery area after completing single orbit; evaluate capability of worldwide Mercury tracking network.	ATLAS-D. *Gross lift-off weight:* 260,000 lb. *Height:* 65 ft. (93 ft. high with adapter section and spacecraft). *Diameter at base:* 10 ft.	*Dimensions:* 9 ft. high; 6 ft. base diameter. *Total payload weight:* 2,700 lb. (approximate). *Instrumentation:* Communications stabilization control, reaction control and environmental control equipment; a crewman simulator to test environmental control systems; 2 playback tape recorders. *Power supply:* Chemical batteries.	Atlas did not follow programed flight path immediately after lift-off and was destroyed by range safety officer at about 16,400 ft. Spacecraft lifted clear of Atlas by escape system and was recovered. Launch provided thorough test of abort and recovery systems.

Table 1.—NASA Satellite and Probe Launchings, Oct. 1, 1960–June 30, 1961—Continued

Name, date, site, lifetime, mission	Launch vehicle	Payload	Test Results
EXPLORER XI (1961 Nu); Apr. 27, 1961 (1–3 years). *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* To orbit a gamma ray astronomy telescope satellite to detect high energy gamma rays from cosmic sources and map their distribution in the sky.	JUNO II. *Stages:* *1st:* Modified Army Jupiter. *2d:* 11 scaled-down solid Sergeant rockets in cluster. *3d:* 3 scaled-down Sergeants in cluster. *4th:* Single Sergeant rocket. *Height:* 76 ft. *Lift-off weight:* 121,000 lb.	*Dimensions:* 12-in. diameter, 23½-inch-long octagonal aluminum box mounted on a 6-inch diameter, 20½-inch-long aluminum instrument column 44-inch-long 4th stage rocket remains with satellite. *Total payload weight:* 82 lb. *Instrumentation:* Includes: Gamma ray telescope consisting of a plastic scintillator, crystal layers and a Cerenkov detector; sun and earth sensors; micrometeorite shield; temperature sensor; damping mechanism. *Transmitters:* 2: 107.97 mc. at 125 mw. for data transmission; 108.06 mc. at 20–25 mw. for tracking. Estimated lifetime: 1 year. Commanded into the "off" mode on Dec. 6, 1961. *Power supply:* Solar cells charged by 12 nickel-cadmium batteries.	Orbit achieved. Vehicle and all payload systems functioned as planned. *Period:* 108.1 minutes. *Orbital path:* Elliptical. *Launch inclination:* 28.8° to the Equator. *Velocities:* Perigee: 17,765 m.p.h. Apogee: 14,933 m.p.h. *Perigee:* 308 (miles). *Apogee:* 1,108 (miles).
EXPLORER; May 24, 1961. *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* To determine ionospheric electron content under quiet and disturbed conditions, study daily and seasonal variations; investigate ionospheric radio wave propagation.	JUNO II. *Stages:* *1st:* Modified Army Jupiter IRBM. *2d:* 11 solid-propellant motors. *3d:* 3 solid rockets. *4th:* Single solid rocket. *Gross lift-off weight:* 121,000 lb. *Height:* 76 ft. *Diameter at base:* 8¾ ft.	*Dimensions:* 30 in. diameter; 24 in. high. *Total payload weight:* 75 lb. *Instrumentation:* Transmitter; aspect sensor; 7 temperature sensors; 2 antennas. *Transmitters:* Single transmitter broadcasting on 6 frequencies at varying levels of power: 20.005; 40.010; 108.02; 360.09; 960.24; 41.010 mc. *Power supply:* Solar cells and nickel-cadmium batteries.	Orbit not achieved. 2d stage failed to ignite.

EXPLORER; June 30, 1961. *Launched from:* Wallops Station, Va. *Mission:* To study performance, structural integrity, and environmental conditions of Scout vehicle and guidance control system. And to investigate the nature of micrometeoroids and their effects on space flights.	SCOUT. *Stages:* *1st:* Algol. *2d:* Castor—a modified Sergeant motor. *3d:* Antares—scaled-up version of 4th stage. *4th:* Altair—modified X-248 Vanguard 3d stage. *Gross lift-off weight:* 36,600 lb. *Height:* 72 ft. *Diameter at base:* 40 in.	*Dimensions:* 76 in. long, 24 in. diameter. *Total payload weight:* 187 lb. *Instrumentation:* Detectors: (1) Pressurized cells of various thicknesses. (2) Foil gages (printed circuit mounted underneath stainless steel samples). (3) Wire grids. (4) Cadmium-sulfide cells. (5) Piezoelectric crystal impact detecting transducers. *Transmitters:* Two separate transmitter-telemetry circuits operating on 136.860 mc. and 136.20 mc., respectively. *Power supply:* Solar cells and nickel-cadmium batteries.	3d stage failed to ignite. Vehicle impacted in Atlantic about 325 miles downrange.

Satellite Applications

NASA Research Points Toward Operational Systems

With the feasibility of meteorological and passive communications satellites proved by TIROS I and Echo I, respectively, NASA research moved ahead toward future operational systems.

In space applications, weather satellites appear to hold almost immediate promise of returning the investment, not only in terms of dollars, but also in terms of savings in human lives and property by providing the data necessary for more accurate forecasting of hurricanes and other severe storms.

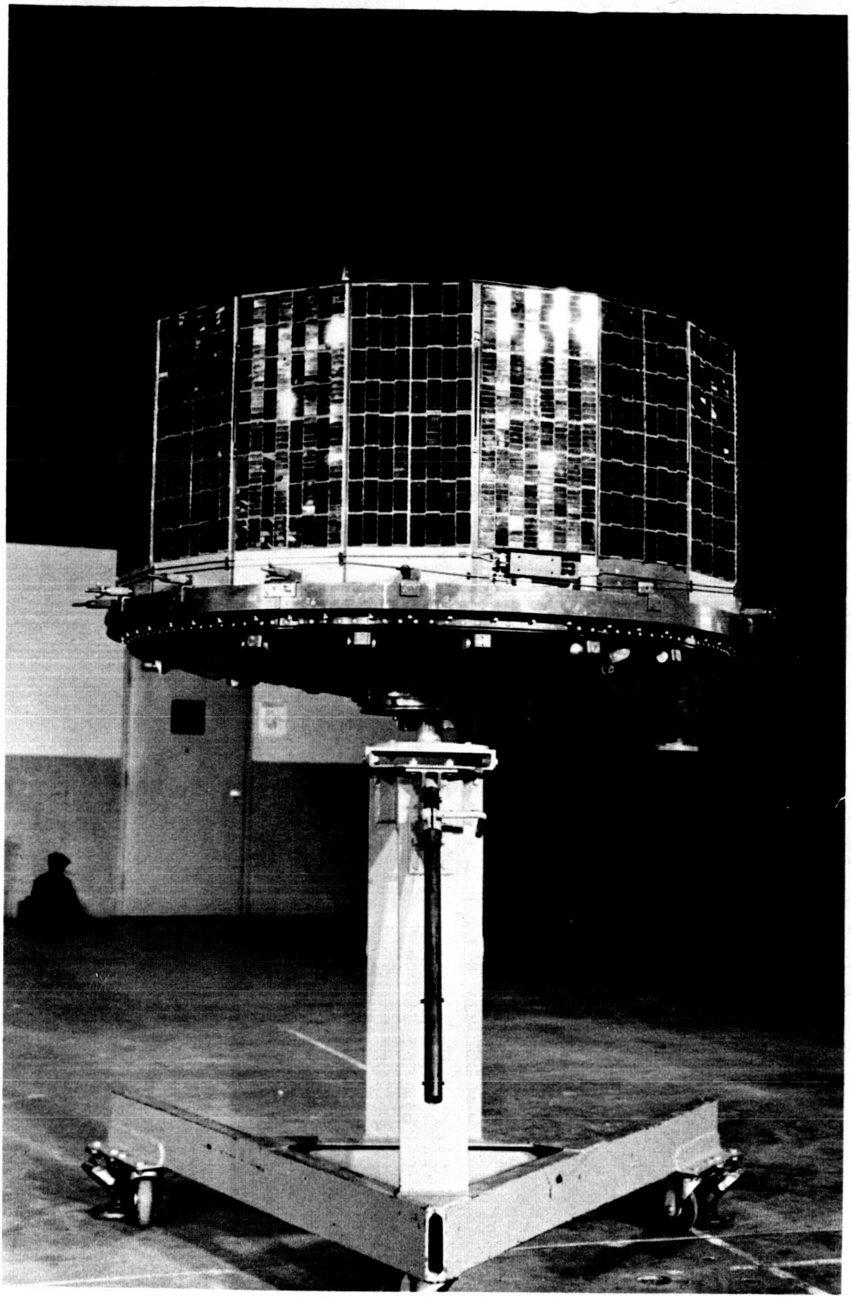
Also promising for the near future are communications satellites—both the passive, or reflective, "balloons" such as Echo I, which can "bounce" radio signals over great distances; and active repeaters, such as the upcoming Relay series, which can receive messages transmitted from the ground and retransmit them to ground stations thousands of miles distant.

During the period, NASA launched one applications satellite, TIROS II, which is discussed below. Communications and meteorological satellites which NASA is preparing for future launchings are described in Chapter 9, "Satellite Development."

TIROS II Weather Satellite

Launched Into Near-Circular Orbit

On November 23, 1960, NASA launched TIROS (Television and Infrared Observation Satellite) II, an experimental meteorological satellite, from Cape Canaveral, Fla. The satellite was designed to obtain data on the earth's cloud cover and heat radiation. Shaped like a drum, 19 inches deep and 42 inches in diameter, the 280-pound satellite was placed in a near-circular orbit (apogee, 453 miles; perigee, 387 miles) by a Delta launch vehicle.



TIROS II, launched November 23, 1960

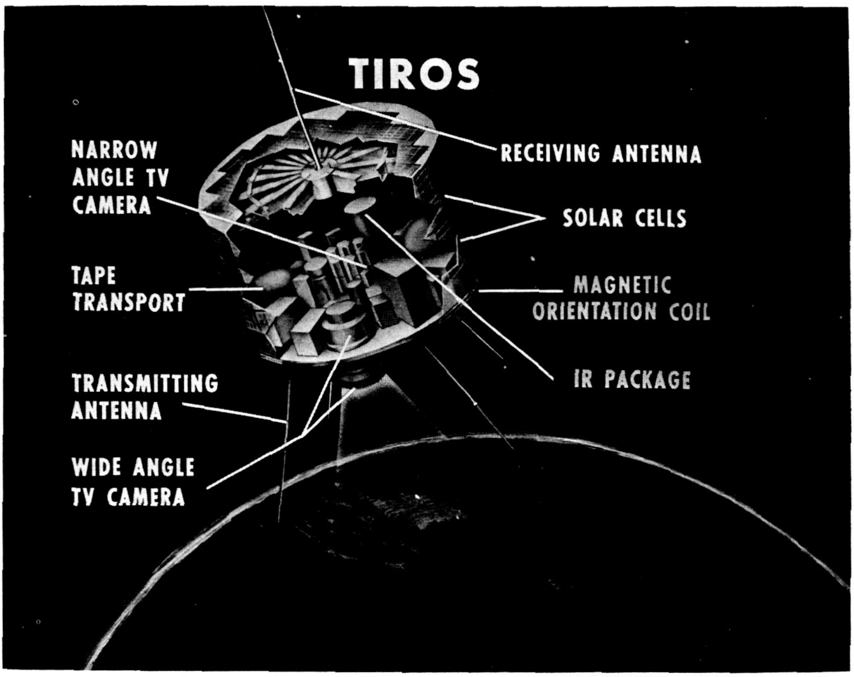
All elements of TIROS II began operating shortly after orbit was achieved, and, as the report period closed, its two television cameras were still photographing cloud cover and other weather phenomena. Despite some problems with the clarity of the wide-angle camera picture, the pictures were extremely useful to meteorologists. All the satellite's infrared radiation sensors except two operated successfully for 5 months. Associated electronic devices and a tape recorder were still active on June 30.

Solar Cells Supply Power

A total of 9,260 silicon cells cover the outer surface of the satellite, producing about 20 watts of power—if all work properly—to recharge the satellite's nickel-cadmium batteries. The cells are treated to aid in throwing off the heat portions of the sun's rays, enabling them to convert sunlight into electrical energy more effectively. The treatment is as if sunglasses were placed on each separate cell. It also protects the silicon surface from micrometeoroids encountered in orbit.

Television Cameras Photograph the Earth

Two TV cameras—each the size of a water glass, with a specially designed ½-inch Vidicon tube—scan the earth from TIROS II. One



camera has a narrow-angle lens for taking comparatively detailed pictures of small areas, about 75 miles square; the other has a wide-angle lens for photographing larger regions (about 750 miles square when the satellite is pointed straight down).

Both camera systems permit direct transmission of pictures when the satellite is within range of the read-out stations at Fort Monmouth, N.J., and San Nicholas Island, a part of the Pacific Missile Range, off the coast of California. Both cameras can also be programed to take pictures over remote areas, to store them on tape recorders, and to transmit them when passing over one of the read-out stations.

Infrared Experiments Measure Solar Energy

TIROS II radiation experiments consist of two types—those measuring the amount of solar energy reflected by the earth, and those measuring the quantity of energy the earth and atmosphere radiate outward. These measurements will assist scientists to understand better the working of the earth's weathermaking "heat balance."

The first of two types of equipment used for these experiments consists of five scanning sensors to measure radiation averaged over areas about 30 miles in diameter. These sensors record (1) the amount of solar radiation reflected from the earth and its atmosphere; (2) the amount of emitted long-wave radiation leaving the earth and its atmosphere; (3) the radiation emitted from the earth's surface or cloud tops in the atmospheric "window," a band of wavelengths where the atmosphere is essentially transparent to radiation; (4) the radiation emitted by water vapor at levels averaging about 25,000 feet above the surface; (5) a crude picture of the cloud distribution.

The second type of radiation-measuring equipment has two sensors covering an area about 450 miles in diameter, centered in the wide-angle camera's field of view. One sensor measures the total radiation reflected and emitted by the earth and its atmosphere. The second measures only the emitted long-wave radiation. By subtraction and by applying knowledge of the sun's radiation, the total energy input and the energy loss of the atmosphere in the area viewed can be computed and studied in relation to the observed cloudiness.

The data from both experiments are recorded on an endless-loop tape recorder which continuously stores the last 100 minutes of observations. These data are transmitted on command when the satellite passes over one of the two ground stations.

Magnetic Coil Controls Position of TIROS II

A magnetic orientation-control coil, consisting of 250 turns of aluminum wire, was placed around the base of TIROS II to permit the

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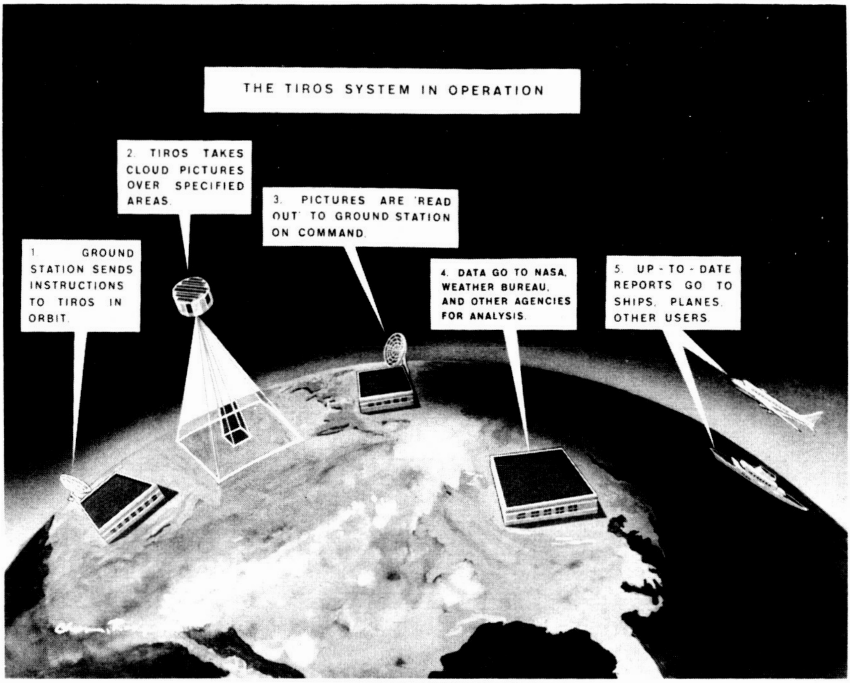


attitude of its spin axis to be changed on command from the ground. TIROS I had changed its attitude in absolute space slowly but continuously because of interactions between the earth's magnetic field and magnetic fields generated by the satellite's own electrical currents. The control coil on TIROS II was designed so that the amount of current flowing through the coil—and so the strength of the magnetic field of the satellite—could be varied. Thus, the position of the satellite could be changed slowly to improve its operation. While the rate of change is far too slow to keep the cameras pointing toward the earth at all times, it does (1) increase the amount of power received from the sun by the solar cells, (2) keep the sun from shining into the radiation sensors, and (3) permit somewhat better TV pictures.

This control device has been used many times during the operation of TIROS II with excellent results. It is a significant advance in attitude control of spin-stabilized satellites.

Cloud Pictures Transmitted

Within 4½ hours after launching, TIROS II transmitted cloud-cover pictures taken by its wide-angle television camera from an altitude of more than 400 miles, over the Dakotas and Northern Plains area. Although the first pictures were of poor quality and could not be used for analyzing weather, after a few days' experience with camera settings and data analysis, daily use began of the analyses on which weather forecasts are based.

The photographs from the wide-angle camera were inferior to those of TIROS I, but nevertheless very useful to weathermen in delineating cloud areas. Pictures from the narrow-angle camera were excellent, and the infrared data met all expectations.

Cameras Operated Without Command

From time to time, both cameras operated without or contrary to command from the read-out stations. The cause is not positively known, although spurious radio signals on the same frequency as the command transmitter were among the causes suspected.

Sea Ice Pictures Obtained

During January and March 1961, the TIROS II cameras obtained excellent pictures of sea ice in or near the Gulf of St. Lawrence. Concurrently, lower-level pictures and other data on the ice were obtained by U.S. Navy aircraft. The data are under study by the Weather Bureau and the U.S. Navy Hydrographic Office.

Specialists concerned with the sea-ice problem believe that meteorological satellites represent a major new tool for research and operational surveillance, particularly when satellites in more highly inclined orbits become available.

International Aspects

NASA and the Weather Bureau invited weather agencies of 21 foreign nations, including the Soviet Union, to participate in the TIROS II experiment by making special ground observations coordinated with passes of the satellite. Pictures taken by the satellite's camera were to be furnished to the cooperating nations for comparative analysis with their own observations. Seventeen countries expressed interest.

When it became obvious that the wide-angle camera was transmitting pictures of poor quality, the participating countries were notified to that effect. However, 10 countries felt the experiment was of sufficient value to continue their observations: Argentina, Australia, Belgium, Czechoslovakia, Denmark, Italy, Japan, the Netherlands, Switzerland, and West Germany.

National Operational Meteorological Satellite System

A plan for a National Operational Meteorological Satellite System under the overall management of the Weather Bureau and with extensive NASA participation (submitted to the President in April 1961), was prepared by the Panel on Operational Meteorological Satellites (POMS). This panel was established in late 1960 under the auspices of the National Coordinating Committee for Aviation Meteorology. Its members are drawn from NASA, the Department of Defense, the Department of Commerce, and the Federal Aviation Agency. In May 1961, the President asked Congress to appropriate $53 million to enable the Weather Bureau to begin putting the plan into effect.

Briefly, the panel proposed prompt development of a meteorological satellite system based on the Nimbus series. New developments from NASA's research and development program, such as the Aeros stationary satellites, would be integrated into the operational system.

Pending the first Nimbus satellite, additional TIROS spacecraft would provide limited experimental operational capability.

CHAPTER 4

Scientific Satellites and Sounding Rockets

Geophysical and Astronomical Studies

NASA's scientific earth-satellite and sounding-rocket programs are principally concerned with geophysics (the study of the earth and its environment, with heavy emphasis on the earth's atmosphere and ionosphere and the sun's influence) and astronomy. These studies not only shed new light on many fundamental scientific problems, but also contribute to progress in NASA's manned-space-flight and satellite-applications programs.

Between October 1, 1960, and June 20, 1961, NASA launched 4 scientific satellites and conducted about 60 sounding-rocket experiments.

Satellite Experiments[1]

Explorer VIII

At 12:23 a.m., e.s.t., November 3, 1960, NASA launched Explorer VIII, a scientific satellite instrumented primarily to gather data on low-energy electrically charged particles in the ionosphere which affect radio communication. The satellite was also equipped to record the frequency, momentum, and energy of micrometeoroid impacts.

The launch vehicle, a Juno II, carried the 90.14-pound satellite into an orbit with an apogee (greatest distance from earth) of 1,420 and perigee (closest approach to earth) of 260 miles. Explorer VIII completed more than 694 trips around the earth, traveling 20,866,706 miles during its operating lifetime from November 3 to December 27, 1960, and providing enough data to fill nearly 700 miles of magnetic recording tape at ground stations.

Analysis of data through June 30, 1961, indicates:

(1) Temperature of the upper ionosphere (250 to about 1,400 miles above earth) is relatively constant at any given time. Explorer VIII made the first actual measurements of electron temperatures at these

[1] Unless otherwise indicated, launchings are from Cape Canaveral, Fla. See table 1 for additional data regarding experiments.

altitudes. Electron temperatures were about 2,700° F. during sunlit hours and about 1,300° F. at night.

(2) Oxygen is the predominant gas up to an altitude of about 650 miles, where a layer of helium begins to predominate, extending to at least 1,500 miles.

(3) The cloud of ions (atoms which have lost or gained an electron) which forms around spacecraft consists chiefly of positive ions ahead of the craft and negative ions in its wake. The effects of this cloud on radar tracking and orbit lifetime are under study.

(4) A relationship exists between the size and quantity of micrometeoroids (cosmic dust). In descending order, the number of micrometeoroids in a given size was found to be substantially greater than that of the next larger size.

Explorer IX

At 8:05 a.m., e.s.t., February 16, 1961, a 12-foot diameter, inflatable sphere was orbited to gather data on the density of the earth's atmosphere at various altitudes. Initial apogee and perigee of this first satellite launched from Wallops Station, Va., were 1,605.5 and 395.2 miles, respectively. A step in Scout-launch-vehicle development, Explorer IX was the first U.S. satellite placed in orbit by an all-solid-fuel vehicle.

Because the satellite's radiobeacon failed soon after launching, Baker-Nunn cameras were employed for tracking. (See Chapter 6, "Tracking and Data Acquisition.") Preliminary analysis of optical data on the satellite's orbit shows that the air density at 400 miles altitude corresponds to theoretical predictions.

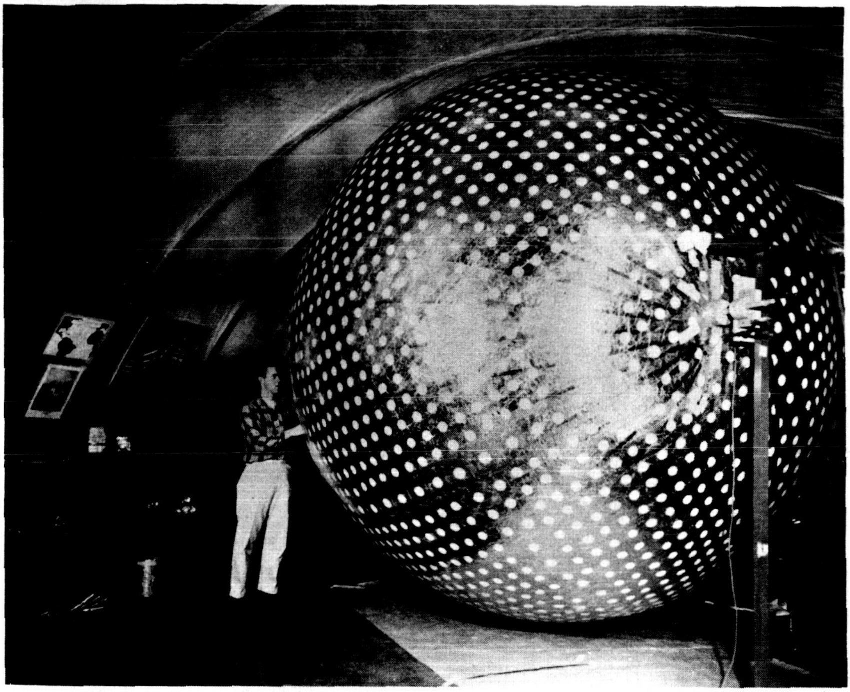
Explorer IX backed up a similar sphere (designated S–56) which failed to attain orbit after launch from Wallops Station on December 4, 1960. (The second stage of its four-stage Scout launch vehicle did not ignite.)

S–45 (Ionosphere Beacon Satellite)

S–45, launched February 24, 1961, failed to orbit because the Juno II launch vehicle malfunctioned. Similar to Explorer VIII in shape, S–45 was instrumented to transmit on several radiofrequencies. Experimenters were to develop information about the structure and characteristics of the ionosphere by studying its effects on reception at the different frequencies.

S–45a (Ionosphere Beacon Satellite)

Orbiting of S–45a, similar to S–45 (above), was not achieved because the second stage of its Juno II launch vehicle failed to ignite. The launch date was May 24, 1961.



Explorer IX test inflated prior to launch. The satellite is being employed to gather data on density of the earth's atmosphere

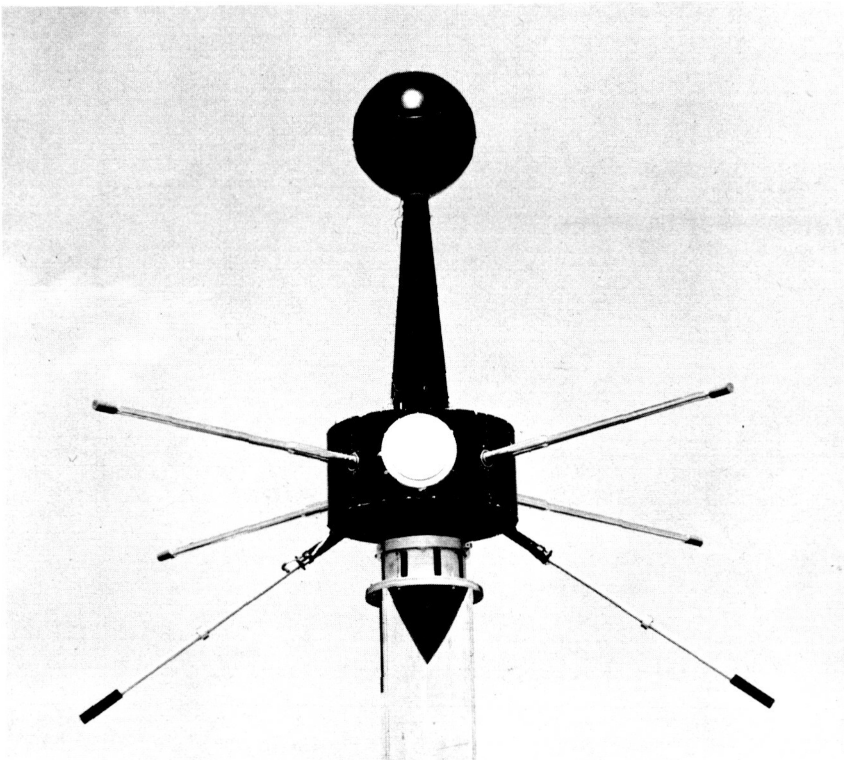
Explorer X

Explorer X, launched by a Delta vehicle at 10:17 a.m., e.s.t., March 25, 1961, was intended to (1) provide extensive data on the earth's and interplanetary magnetic fields, and (2) help determine how these fields affect and are influenced by solar plasma (low-energy electrified particles hurled from the sun during solar flares, also called the solar wind). Understanding of these phenomena is essential in order to assess radiation and protect man from the hazards of lunar and interplanetary flight.

The 78-pound satellite's orbit carried it about 145,000 miles from earth at apogee, which it reached at 3:40 a.m., e.s.t., March 28, 1961. Launched at near-escape velocity, about 24,000 m.p.h.,[2] Explorer X was the first U.S. spacecraft of its type to travel into deep space. It transmitted data for 64 hours, 9 hours longer than expected.

The timing of the shot was fortunate: portions of the Explorer X flight were during periods when magnetic fields were relatively calm, but the satellite also recorded data when the fields were agitated by a solar storm. At 10:05 a.m., e.s.t., March 27, 1961, U.S. ground in-

[2] Escape velocity is approximately 25,000 m.p.h.



Explorer X, launched March 25, 1961, to obtain information chiefly about magnetic fields in space

struments recorded a magnetic disturbance believed caused by an advancing solar wind. At this time, Explorer X was on the side of the earth away from the sun. About 2 minutes later, the satellite transmitted data identical with that recorded by earth instruments, indicating that the speed of the solar wind was about 3.26 million miles per hour.

Analysis of data transmitted by Explorer X indicated that:

(1) Part of the interplanetary magnetic field near the earth may be an extension of the sun's magnetic field. The solar wind or plasma [3] hurled into space by a solar flare appears to carry the sun's magnetic field with it.

(2) Low-energy plasma surrounds the earth up to an altitude of about 16,000 miles. Between 16,000 and 80,000 miles, little plasma is present, but another plasma belt, presumably originating from the sun, extends from 80,000 miles to at least 145,000 miles, the maximum altitude of Explorer X.

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[3] "Plasma"—electrically charged gas.

(3) The earth's magnetic field stretches at least 24,000 miles, a distance nearly corresponding to that predicted by theoretical calculations.

(4) Magnetic fields fluctuate sharply in direction and intensity.

(5) A strong interplanetary magnetic field exists beyond 80,000 miles from earth.

Some of the above phenomena had been reported by earlier probes such as Pioneers I and V, but Explorer X gathered much additional data.

Explorer XI

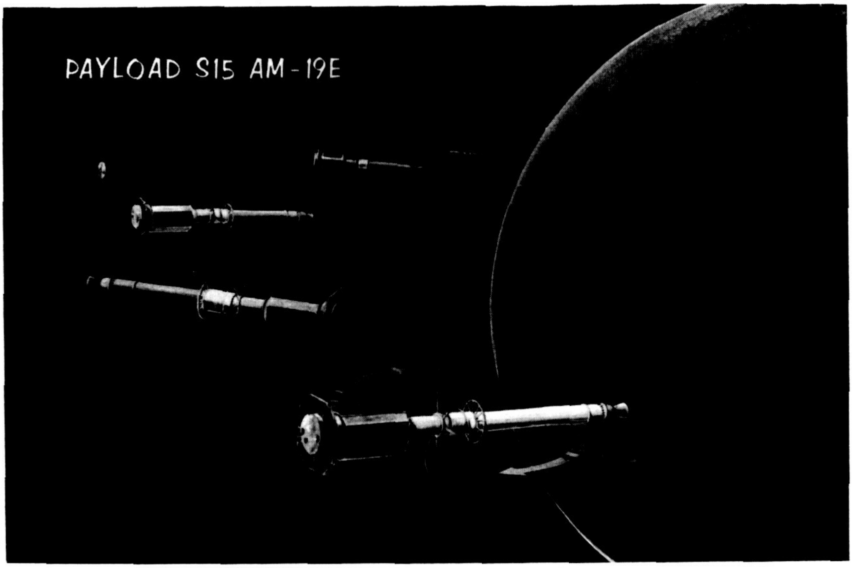
The first step of a long-range program to lay bare the secrets of the universe began with the launch of Explorer XI, first of NASA's astronomical satellites, at 9:17 a.m., e.s.t., April 27, 1961. A Juno II launch vehicle placed the 82-pound satellite (an octagonal aluminum box, 12 inches in diameter and 23½ inches long, mounted on an instrument column 6 inches in diameter and 23½ inches long) into an initial orbit of about 1,108 miles[4] at apogee and 308 miles at perigee. In orbit, the satellite, resembling an old-fashioned street lamp, tumbled end over end 10 times a minute, enabling its instruments to scan a different region of space every 6 seconds. The aim: to detect, and aid in determining sources of, gamma rays[5] and other forms of cosmic radiation streaming earthward from outer space.

Cosmic rays, being high-energy charged particles, are scattered over the entire galaxy by random magnetic fields in space. Therefore, any hint of the direction from which they came is lost by the time they reach the vicinity of the earth. However, a source of cosmic rays will also be a source of gamma rays, because the latter are emitted when cosmic rays interact with matter. Since gamma rays—like light—travel in straight lines, scientists may discover a source of cosmic-ray generation by analyzing the direction of a gamma-ray stream.

Scientists are particularly interested in gamma radiation because of its associations with nuclear reaction and energy creation. Data provided by Explorer XI may help to evaluate some theories on the origin, characteristics, and growth of the universe, predicated on the belief that matter is continuously being created from energy. Among the theories are the following: Stars are a major contributor to cosmic rays within our galaxy; cosmic rays are produced as an aftermath of star explosions (novae and supernovae); and half the

[4] Somewhat higher than planned. As a result, the satellite's orbit passed through part of the Van Allen radiation region. When the satellite was in the region, Van Allen radiation masked gamma radiation from space, preventing acquisition of useful data.

[5] Gamma rays, a form of electromagnetic radiation, are extremely penetrating; they can, for example, pass through a sheet of lead more than an inch thick. They are blocked by the earth's atmosphere, and must, therefore, be studied from satellite altitudes.



Artist's conception of Explorer XI, the first astronomical satellite, in orbit

matter in our galaxy is concentrated in stars while the other half remains in space as the source material for new stars.

In connection with the latter theory, measuring the intensity of gamma rays from sources other than stars may permit scientists to make a rough calculation of the quantity of interstellar matter.

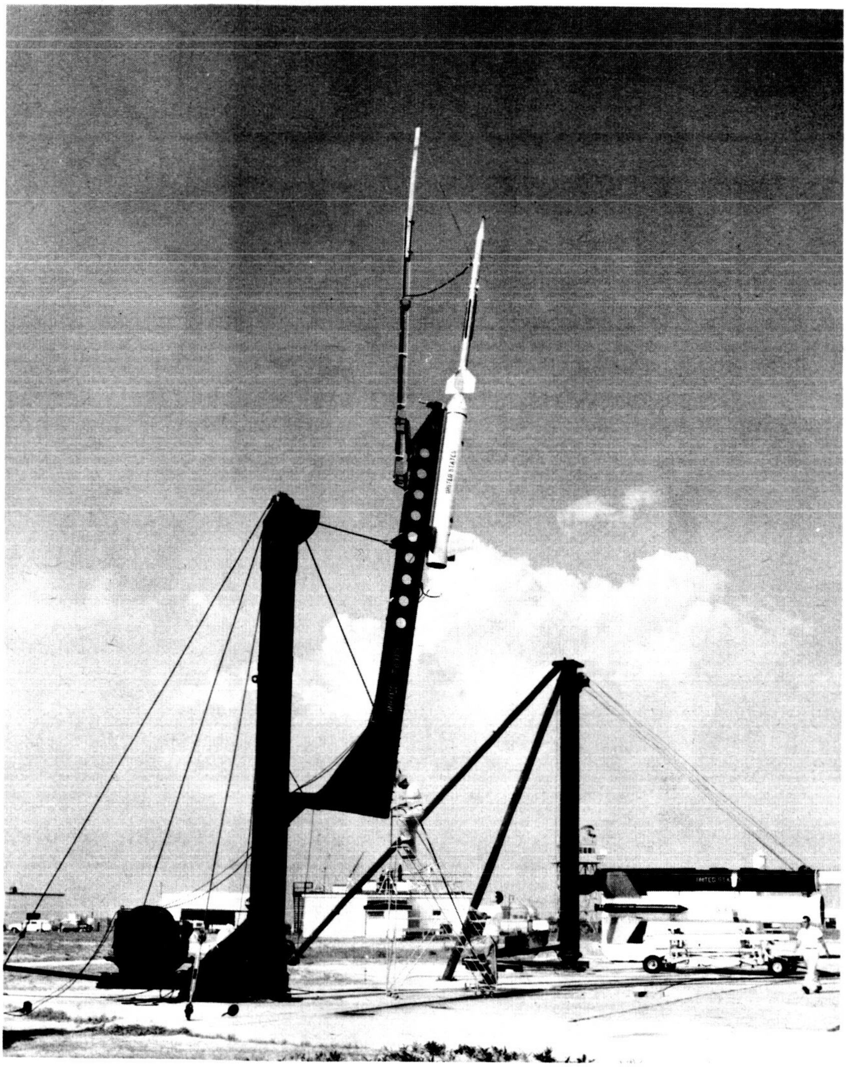
S–55 (Micrometeoroid Hazard Satellite)

On June 30, 1961, NASA fired a Scout launch vehicle carrying a payload instrumented for study of micrometeoroids (cosmic dust). Primary purpose of this flight from Wallops Station, Va., was to carry out the fifth Scout developmental flight. The secondary objective was to gather data on micrometeoroid density and effects of micrometeoroid bombardment on space vehicles and instruments. Orbit was not attained because the Scout third stage failed to ignite.

Sounding Rockets

Sounding rockets are used principally to supplement the scientific data transmitted by satellites. Because they are relatively easy to launch and can be fired from almost anywhere, sounding rockets are ideal for gathering scientific information either about a specific event—such as a solar storm—or about a particular area or location. They are also the most practicable vehicles for studies of the atmosphere at altitudes from 20 miles (maximum balloon altitude) to 150 miles (where air drag would seriously limit a satellite's life). In addition, sounding rockets test instruments, equipment, and power supplies for future satellites and launch vehicles.

Typical sounding rocket experiments during the report period are described below.



Nike-Cajun ready to be launched for research on upper atmosphere winds and temperatures

Sodium-Vapor Experiments

As part of a continuing study of upper atmosphere wind velocities, directions, and temperatures, NASA conducted a series of sodium-vapor experiments at Wallops Station, Va., on December 9–10, 1960. A two-stage Nike-Cajun rocket carrying the first sodium-vapor package was launched at 6:20 a.m., e.s.t., December 9, the sodium vapor being ejected at an altitude of 55 miles.

Another launch at 5:15 p.m., e.s.t.—just after sunset—failed when the second stage of the Nike-Cajun did not ignite. The rocket reached an altitude of 80,000 feet, too low for the cloud to be visible. A minimum altitude of 140,000 feet (about 26 miles) is required for this experiment to be successful.

In the third experiment at 5:30 p.m., e.s.t., December 10, the sounding rocket ejected a sodium-vapor cloud at an altitude of about 212 miles and released a lithium flare near its peak altitude of about 450 miles.

Solar-Beam Experiments

Nine Nike-Cajuns with solar-beam payloads were launched from Fort Churchill, Canada, during November 1960. Solar-beam payloads include recoverable packages of photographic emulsions and energetic particle detectors, used to gather data on cosmic rays emitted by the sun during solar flares and sunspot eruptions. Such solar upheavals create a severe radiation hazard for manned space flight. NASA recovered seven of the emulsion packages and was analyzing the cosmic-ray tracks in the emulsions, as well as other flight data, when this reporting period ended.

Meteorological-Satellite Program Support

On October 5, 1960, NASA launched an Aerobee sounding rocket from Fort Churchill, Canada. The rocket's payload—camera and film—photographed clouds before dropping to earth where it was recovered. The pictures were obtained to aid in preparing for interpretation of Arctic cloud-cover photographs taken by later weather satellites. On May 17 and 19, NASA launched two camera-equipped Aerobees from Fort Churchill to photograph snow from high altitudes. Here the purpose was to devise techniques for distinguishing cloud cover from snow in weather-satellite pictures.

Astronomical Studies (Ultraviolet)

An Aerobee-Hi sounding rocket was launched March 31, 1961, to photograph ultraviolet radiation from the stars. Ultraviolet photographs provide valuable information on the makeup and evolutionary processes of the stars. Ultraviolet radiations cannot be photographed from earth because they are largely screened out by the atmosphere.

Support of Centaur-Launch-Vehicle Development

On February 6, 1961, NASA launched an Aerobee-Hi containing a sphere partially filled with liquid hydrogen as part of its payload. Other instruments included equipment to record behavior of the liquid hydrogen under conditions of zero gravity.

A study of liquid-hydrogen behavior in zero gravity is an important part of Atlas-Centaur launch-vehicle development. Centaur, the upper stage of the Atlas-Centaur launch vehicle, will be the first U.S. rocket to burn liquid hydrogen and liquid oxygen instead of kerosene and liquid oxygen. (See Chapter 7, "Launch Vehicle Development.")

United States-Italian Cooperative Experiment

Probe Atmospheric Motions.—In April 1961, NASA and Italian scientists coordinated sounding-rocket launchings to study atmospheric motions and wind jets between about 50 and 150 miles altitude. These experiments were a first step toward eventual studies—with satellites and sounding rockets—of the worldwide upper atmosphere tides similar to oceanic tides. The rockets carried sodium-vapor payloads which, when released at a proper altitude in twilight, appear as orange-yellow clouds.

NASA launched the first rocket from Wallops Station, Va., at dawn on April 19. At dusk, 9 hours later, the Italians fired their first rocket from Perdas de Fogu, Sardinia. During the next few days the remaining experiments were launched at similar intervals.

Other Experiments

(All launches were from Wallops Station unless otherwise indicated.)

... Argo D-4, November 9, 1960, to measure the positive ion composition of the upper atmosphere. It reached an altitude of about 650 miles.

... Nike-Cajun, December 8, 1960, to measure electron density and temperature in the ionosphere by means of a Langmuir double-probe technique.

... Javelin, December 12, 1960, to measure magnetic fields and hydromagnetic waves from the base of the ionosphere to the base of the Van Allen radiation region.

... Nike-Cajuns, April and May 1961, with payloads consisting of grenades timed to explode at intervals during flight. Measurements of time for sound waves to reach earth indicated the temperatures and wind velocities at differing altitudes.

... Nike-Cajun, June 6, 1961, with three spheres of varying weights and sizes in atmospheric-drag experiments. One globe contained an accelerometer to indicate its rate of fall; the two lighter spheres were tracked by radar.

...Javelin firings, April and June 1961, to test instruments that will be used in the Canadian topside sounder satellite (Alouette), the U.S. fixed-frequency topside sounder satellite, and a future space probe.

CHAPTER 5

Unmanned Lunar and Interplanetary Programs

Exploration of the Moon

A major purpose of the unmanned lunar exploration program is to study the moon for clues to the history of the earth-moon system and the origin of the planets and natural satellites in our solar system. Another is to acquire data about the lunar surface and environment for use in planning missions and designing equipment for manned exploration.

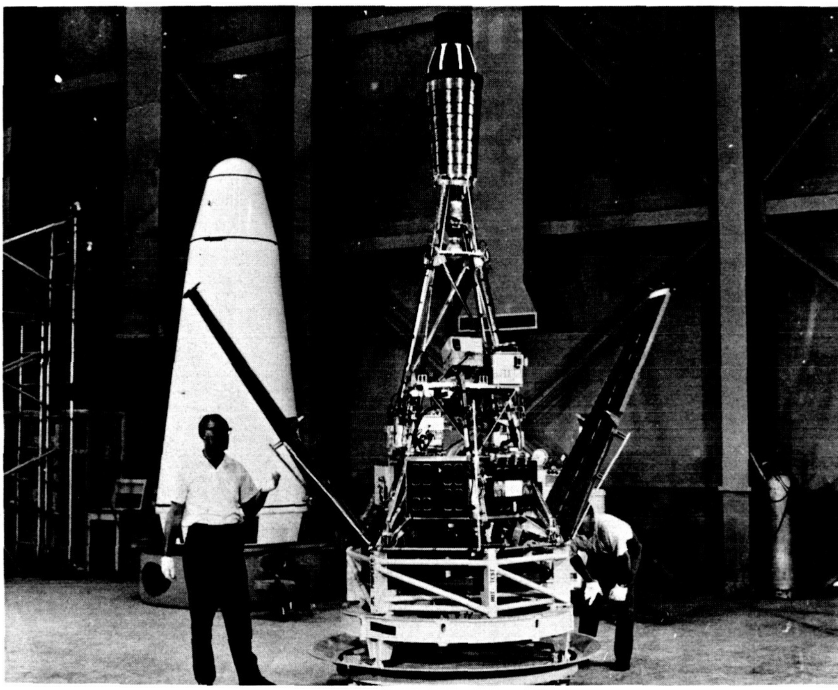
Scientific experiments are directed toward determining characteristics of the lunar landscape and of surface features, surface and subsurface structure, physical properties, chemical and mineralogical composition; the properties of the moon as a planetary body; and the thermal history of the moon. Chemical analysis of surface dust may lead to the discovery of organic molecules, precursors of living organisms, in the layers that have accumulated on the lunar surface over many eons. This research may prove of immeasurable importance to the biological sciences; it may, indeed, provide clues to the origin of life on earth.

Ranger

The Ranger project is designed to gain information about the surface characteristics of the moon and to land the first survivable instrumented capsule. Checkout of the first Ranger spacecraft, to be launched by an Atlas-Agena B booster during the third quarter of 1961, is near completion. Subsequent spacecraft are in various stages of assembly and systems testing. The basic Ranger spacecraft is being developed at the Jet Propulsion Laboratory, Pasadena, Calif.; the survivable lunar capsule system, at the Aeronutronic Division of Ford Motor Co., Newport Beach, Calif.

Rangers 1 and 2.—The first two Ranger spacecraft will be simpler in design than those to follow. Their missions are to (1) test basic design and advanced engineering features of the lunar spacecraft, and (2) obtain scientific data on interplanetary space, such as magnetic fields, energetic particles from solar and cosmic radiation, micrometeroids, and the hydrogen cloud that envelops the earth.

Advanced Rangers.—Later Rangers are designed to rough-land on the moon survivable "capsules" containing scientific instruments and radio transmitting equipment. (The capsules' crushable balsawood structures will absorb the shock of landing and protect instruments and equipment.) These spacecraft will have, in addition to the attitude-control system of the first two Rangers, a midcourse guidance system to insure a collision course to the moon. As the spacecraft approaches the moon, it will transmit to earth television pictures of the lunar surface, along with data from a gamma-ray spectrometer which will reveal whether the moon's crust contains a high concentration of radioisotopes—thus furnishing evidence about its chemical composition.



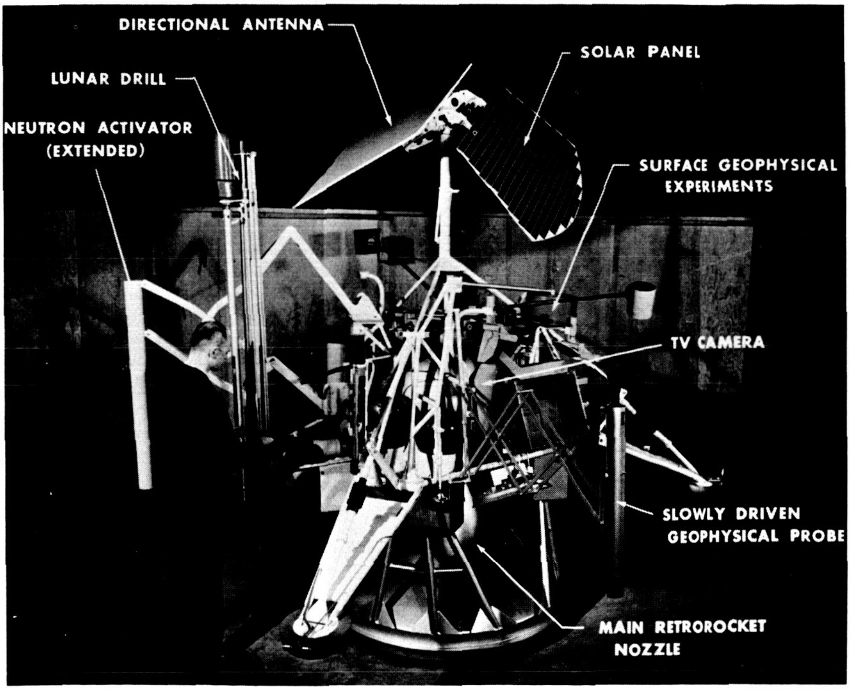
Technicians at Jet Propulsion Laboratory, Pasadena, Calif., check action of solar cell panels on Ranger I lunar spacecraft

The rough-landing capsule will be separated from the spacecraft and slowed by retrorocket so as to impact the moon at about 150 miles per hour. The spacecraft will crash on the moon at about 6,000 miles per hour. The primary experiment in the landing capsule is a seismometer to record and transmit to earth data on "moonquakes" and other possible disturbances originating within the moon; the device will also record meteorite impacts. Seismic measurements can answer fundamental questions about the interior of the moon and provide clues to its origin.

Surveyor

On July 11, 1960, after reviewing proposals by 37 companies, NASA awarded contracts to Hughes Aircraft Co., McDonnell Aircraft Co., North American Aviation, Inc., and Space Technology Laboratories, Inc., for competitive preliminary design studies of the Surveyor lunar soft-landing spacecraft. On January 19, 1961, following evaluation of the designs, NASA selected Hughes Aircraft Co. as contractor for the Surveyor spacecraft system. Development of Surveyor is underway at the Hughes plant in Culver City, Calif.

Surveyor, to be launched by an Atlas-Centaur vehicle, will be the first U.S. spacecraft capable of a controlled soft landing on the moon. Its automatic landing system is designed to decelerate the spacecraft from an approach velocity of about 6,000 miles per hour (9,000 feet per second) to a touchdown speed of about 10 feet per second (the same as the design vertical landing speed of commercial transport airplanes).



Scale model of Surveyor lunar spacecraft showing principal scientific instrumentation

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The gross weight of the spacecraft will be about 2,300 pounds, about two-thirds of which will be rocket propellants used in the landing maneuver, leaving a landed weight of about 750 earth-pounds. Included in this weight are about 250 pounds of experimental equipment.

Surveyor will contain a variety of experimental equipment, including:

(1) Five television cameras to provide pictures of the moon's surface before, during, and after landing; almost microscopic closeups of lunar surface material; and views of some scientific equipment operation for monitors on earth.

(2) A drill and transport system for acquiring and processing samples of lunar surface and subsurface material, and conveying them to apparatus for analysis of chemical and mineralogical composition and other physical properties.

(3) Surface geophysical experiments, lunar atmosphere samplers, radiation detectors, seismometers, magnetometers, and other experiments to define the properties of the moon and its environment.

Lunar Orbiters

A step beyond Surveyor will be the adaptation of its soft-landing system to lunar orbiting missions. The orbiters will be interspersed with the soft-landers for extensive mapping and to provide data on the moon's shape and mass distribution, magnetic field and radiation environment, and other characteristics better determined by orbiting than by landing. NASA is conducting studies to determine the modifications required to convert Surveyor into a lunar-orbiting spacecraft.

Prospector

Prospector is planned as a large versatile "space truck" launched by Saturn and capable of soft-landing on the moon virtually any type of payload, such as:

(1) A self-propelled, remotely controlled, roving surface vehicle for instrumented exploration of large areas.

(2) A system for acquiring samples of lunar material and sending them to earth for more detailed study than can be accomplished by remotely controlled instrumentation on the moon.

(3) Large propellant tanks to enable the spacecraft to hover and move laterally above the lunar surface, thus permitting low-altitude reconnaissance and site selection for subsequent manned landings.

(4) Supplies, shelter, and other logistic support for manned operations on the moon.

NASA's Jet Propulsion Laboratory is conducting preliminary studies of engineering requirements for the Prospector spacecraft.

Pioneer

On December 15, 1960, a Pioneer spacecraft programed for a lunar orbit was destroyed about 70 seconds after launch when its Atlas-Able launch vehicle exploded.

Interplanetary Exploration

Even as NASA prepares for the flight to the moon, it is developing instrumented craft for reconnaissance of Venus and Mars. Among data gathered by these craft, man may find the answer to a question that has intrigued him for centuries—do earth's planetary neighbors harbor life?

Progress on instrumented spacecraft for early missions to Mars and Venus is described below.

Mariner R

Mariner missions will enable science to obtain its first nearby observations of Venus and to test basic elements of space technology needed for future interplanetary missions. Mariner is designed to pass in the vicinity of its planetary target.

Jet Propulsion Laboratory completed preliminary design of Mariner in November 1960. By June 1961 the laboratory had finished engineering design and was testing prototype hardware.

NASA has scheduled the first two Mariner launches for the summer of 1962 during the Venus "launch window"—a brief time interval when the relative positions of Earth and Venus permit minimal propulsive power or maximum payload weight for interplanetary journeys. For example, a launch vehicle that could send a 1,300-pound payload to Venus during the launch window could, at any other time, send only 800 pounds to the planet.

NASA had originally planned to use Atlas-Centaur as the launch vehicle for Mariner. Because Atlas-Centaur will not be ready for operational use for some time after the 1962 launch window, NASA plans to employ the Atlas-Agena B booster for the first Mariner launches. Since the Atlas-Agena B has far less power than Centaur, NASA has had to reduce the weight (and number of experiments) originally planned for the first Mariners. This lighter version is designated Mariner R.

Experiments for the first two Mariner R missions include:

(1) Infrared radiometer—to measure intensity of infrared radiation. Experimenters are from the University of Nevada, Reno, Nev.; the University of California, Berkeley, Calif.; and the Jet Propulsion Laboratory, Pasadena, Calif.

(2) Microwave radiometer—to provide information about temperatures of the surface and lower atmosphere of Venus. Experimenters are from the Jet Propulsion Laboratory; Harvard University, Cambridge, Mass.; Massachusetts Institute of Technology, Cambridge, Mass.; University of Michigan, Ann Arbor, Mich.; and Army Ballistic Missile Agency, Huntsville, Ala.

(3) Fluxgate magnetometer—to obtain measurements of the distant geomagnetic field for further study of currents and hydromagnetic waves and to determine the nature of a Venus magnetic field. Experimenters are from NASA Headquarters, the Jet Propulsion Laboratory, and California Institute of Technology, Los Angeles, Calif.

(4) Radiation detectors—to obtain, in different energy ranges, measurements of charged-particle radiation. Instruments include an ion chamber, Anton 213 counters, a Geiger counter telescope, and a Geiger counter. Experimenters are associated with the California Institute of Technology; the Jet Propulsion Laboratory; State University of Iowa, Iowa City, Iowa; and Goddard Space Flight Center, Greenbelt, Md.

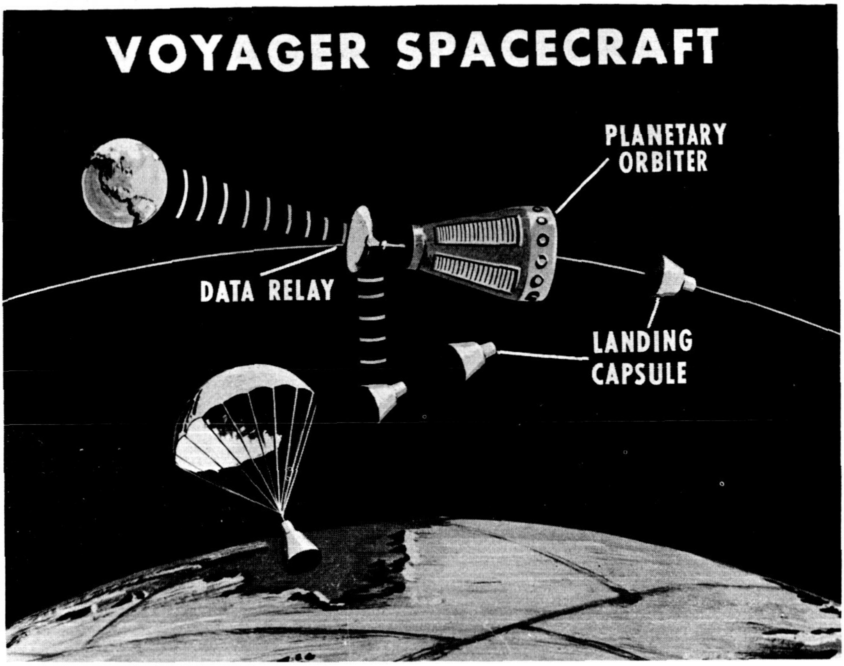
(5) Plasma measurements—to obtain various data on low-energy protons and electrons, using Faraday cup analyzers. Experimenters are associated with the Jet Propulsion Laboratory.

(6) Micrometeoroid (cosmic dust) experiments—to measure momentum, density, and other properties of micrometeoroids. Goddard Space Flight Center is the experimenter.

Mariner B

During the period, NASA considered a wide range of designs for Mariner B, programed for launch toward Venus and Mars in 1964. Just as the technology of Mariner R was based on Ranger, the technology of Mariner B will be based on Mariner R. However, the availability of the Atlas-Centaur launch vehicle, technological progress, and distinctive requirements of the Mars mission all will make possible and necessary a Mariner craft more advanced than Mariner R.

For example, Mariner B may be capable of carrying and launching a small instrumented capsule which would enter the atmosphere of and land on Mars. The spacecraft would continue on a trajectory passing Mars. As the period ended, NASA continued studies of the capsule and of advanced subsystems for Mariner B.



Voyager

NASA is studying a spacecraft called Voyager that would be launched by an advanced Saturn and go into orbit around Mars or Venus. This craft would be designed to transmit information about the target planet and to drop an instrumented capsule to the surface of the planet. The capsule would send data to deep space receiving stations on earth via the orbiting Voyager.

Tracking and Data Acquisition

Four Major Networks

NASA tracks, commands, and gathers information from spacecraft by means of four worldwide ground systems: (1) *Minitrack*, for unmanned satellites; (2) *deep-space instrumentation facilities* (*DSIF*), for spacecraft on lunar or interplanetary flights; (3) *Mercury*, developed to meet the special requirements of manned space flight; and (4) *optical*—including the precision Baker-Nunn telescopic-camera stations and volunteer "Moonwatch" teams, for unmanned satellites.

Minitrack

Coverage Extended

NASA has added four high-latitude stations to increase coverage of satellites in polar and in high-inclination east-west orbits. During the report period, construction of the station at Winkfield, England, neared completion; the St. John's, Newfoundland, and Fairbanks, Alaska, stations were scheduled for occupancy in the fall of 1961. The remaining high-latitude station in the expansion program, at East Grand Forks, Minn., had been built before this period.

New Frequencies

By June 30, 1961, all Minitrack stations had new antennas for the 136- and 137-megacycle frequencies allocated to the United States by the International Telecommunications Union. The new frequencies replaced the interim 108-megacycle frequency assigned to Minitrack during the International Geophysical Year.

Large Antennas

NASA is installing advanced ground equipment to meet demands of the increasingly numerous instruments in future satellites. The plan is to set up at several locations ultrasensitive, 85-foot-diameter antennas for gathering data from such spacecraft as the Nimbus weather satellite, the Orbiting Astronomical Observatory, and the Orbiting Geophysical Observatory.

NASA expects to complete installation of an 85-foot-diameter antenna at Fairbanks, Alaska, by mid-1962. This ground equipment will obtain data from Nimbus and from the Polar Orbiting Geophysical Observatory.

Automatic Data Read-Out System

NASA is procuring automatic data read-out equipment for the Minitrack network. The new equipment is expected to improve accuracy of data processing and increase by about 50 percent the volume of data that each station can acquire.

Locations

In addition to high-latitude locations indicated above, Minitrack stations are at Fort Myers, Fla.; Blossom Point, Md.; Goldstone, Calif.; Quito, Ecuador; Antofagasta, Chile; Santiago, Chile; Lima, Peru; Woomera, Australia; and Johannesburg, Republic of South Africa. NASA has decided to discontinue effective July 1, 1961, another station on Antigua, British West Indies, because it is no longer needed.

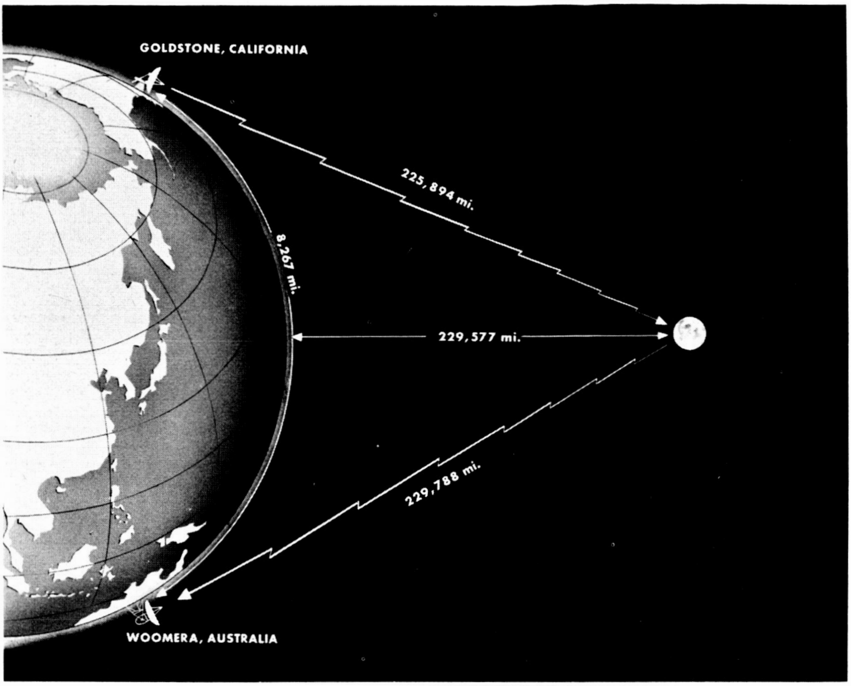
Deep-Space Instrumentation Facilities (DSIF)

Description

NASA can maintain continuous communication with lunar and interplanetary spacecraft through three deep-space instrumentation facilities, each equipped with one or more 85-foot-diameter, parabolic antennas and associated equipment. The facilities are located at Goldstone, Calif.; Woomera, Australia; and Hartebeesthoek, Republic of South Africa. Their locations, approximately 120 degrees of longitude apart, assure at least one line-of-sight communication with a spacecraft despite the earth's rotation.

Construction Progress

The Woomera station was dedicated February 10, 1961, in a ceremony that featured direct voice transmission from Goldstone to Woomera by reflecting radio signals from the moon. The approximately 8,000 miles covered are the longest distance to date for this type of experiment. (See Chapter 15, "International Programs," for additional information on the ceremony.)



Artist's conception of long-distance communication from the Goldstone to Woomera deep-space tracking stations

When the Hartebeesthoek station is completed in the summer of 1961, the network will be fully operational. The Goldstone station was completed before this report period.

Goldstone Conducts Venus Experiment

On May 10, 1961, the Goldstone DSIF completed a 2-month experiment during which it bounced radar signals from Venus to obtain scientific data. The research covered a period before and after April 11, 1961, when Venus and the earth were nearest each other (26.3 million miles apart).

Through the experiment, NASA defined more accurately the value of the astronomical unit (AU)—the mean distance from the earth to the sun—which is basic to celestial measurements. One of the two 85-foot-diameter antennas used in the experiment transmitted radar signals to Venus. The other antenna, 7 miles away, received the reflected signals.

Knowing the signals travel at the speed of light, NASA scientists calculated the distance to Venus and from this determined the AU. Thus, they reduced the uncertainty factor in the AU, previously about

50,000 miles, to about 300 miles. On the basis of the new figure, the distance from earth to the sun is estimated at 92,956,000 miles.

Other experiment data indicated that Venus may rotate about once every 225 earth-days and may have a rough surface similar to that of the moon.

Knowledge gained from this research will be applied in launching the first Venus probe and other interplanetary spacecraft.

Mercury

The principal consideration in developing ground equipment for manned space flight is the necessity for constant vigilance to assure the astronaut's safety. Thus, the system must have redundant and backup equipment which will promptly replace any unit that fails. Another requirement is instrumentation that can track the spacecraft and acquire and process data far more quickly than equipment adequate for unmanned spacecraft.

Description of Network

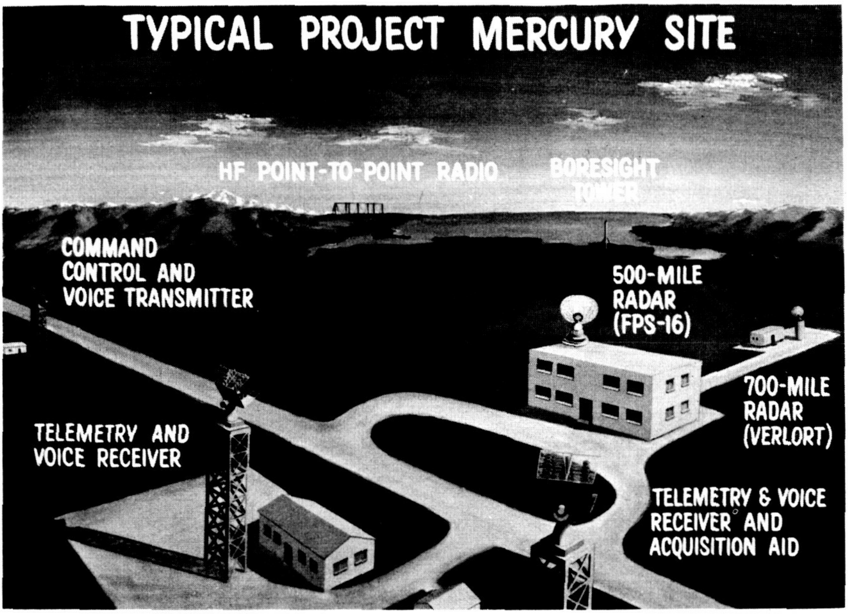
The Mercury network, incorporating the highest possible standards of ground instrumentation, was complete by the end of the period. The network will provide nearly continuous ground control, monitoring, and communication with the Mercury capsule from launch to landing.

The Mercury Control Center at Cape Canaveral, Fla., handles all aspects of flight, coordinates the principal tracking stations, and maintains a smooth flow of information. A station on Bermuda, which serves as an extension of the control center, confirms insertion of the capsule into orbit.

Other stations, in the order that the Mercury capsule will pass over them, are: A ship in the Atlantic Ocean; Grand Canary Island; Kano, Nigeria; Zanzibar; a ship in the Indian Ocean; Muchea and Woomera, Australia; Canton Island; Kauai Island, Hawaii; Point Arguello, Calif.; Guaymas, Mexico; White Sands, N. Mex.; Corpus Christi, Tex.; Valparaiso, Fla.; and Grand Bahama and Grand Turk Islands (both part of the Atlantic Missile Range).

At Goddard Space Flight Center, Greenbelt, Md., a central computing and communications center makes orbital and entry computations and provides communication links between the Mercury Control Center at Cape Canaveral and stations as far distant as Hawaii and Australia.

Among the center's vital tasks are computing and recommending to flight-control officers at Cape Canaveral the exact time and place that the capsule should fire its retro (braking) rockets in order for



the capsule to land in the predetermined recovery area. The center's complex computers produce their recommendations by comparing data from Mercury tracking stations with data from the preset flight course.

Optical Network

Tracks Explorer IX

Data from Explorer IX, the 12-foot-diameter inflatable satellite launched February 16, 1961, might have been lost to science without NASA's optical tracking network. The 12 Baker-Nunn precision telescopic cameras of the network provided invaluable backup service to Minitrack after the satellite's radiobeacon failed. NASA is using data originating from Baker-Nunn photographs of Explorer IX in atmospheric density experiments.

Role of Optical Network

Two uses of the optical network—to back up ground radio stations and to study atmospheric densities at differing altitudes, geographic locations, and seasons—are demonstrated in the Explorer IX experiment. In addition, optical data is employed in geodesy—the determination of exact distances and precise shapes of land and sea areas on earth.

Baker-Nunn camera systems make approximately 2,000 satellite observations per month. This rate could be doubled, if necessary, by adding personnel.

Because of the Baker-Nunn camera's bulk and narrow field of view, its operator must know the approximate orbit and location of a satellite before he can focus on it. Such information is provided by Moonwatch teams using relatively simple telescopic equipment. The teams consist of about 2,000 volunteers distributed among 43 stations in the United States and 52 in 18 foreign countries.

Locations of Baker-Nunn Cameras

Baker-Nunn camera systems are located at: Organ Pass, N. Mex.; Woomera, Australia; Mitaka, Japan; Arequipa, Peru; Curacao, Netherlands West Indies; Villa Dolores, Argentina; Olifontsfontein, Republic of South Africa; San Fernando, Spain; Naini Tal, India; Shiraz, Iran; Jupiter, Fla.; and Haleakala, Hawaii. They are under technical direction of the Smithsonian Astrophysical Observatory, Cambridge, Mass.

Advanced Research and Development

Research and development in tracking, communications, and in the acquisition of data from satellites and space probes, emphasize (1) data-storage capacity of spacecraft; (2) use of MASER's (Microwave Amplification by Simulated Electron Radiation) and parametric amplifiers to reduce noise generated in receiving systems; (3) studies of optimum coding techniques to permit maximum transfer of information with minimum loss of transmission time; (4) automated tracking data reduction; and (5) evaluation and processing of scientific information to keep pace with both the expanding rate of investigations and the rapidly increasing volume of data.

Launch Vehicle Development

National Launch Vehicle Program Moves Forward

United States mastery of space will advance only as rapidly as it can build a fleet of reliable launch vehicles to perform an assortment of tasks—orbit many kinds of scientific payloads and manned capsules, drive spacecraft to the moon, and loft multiton interplanetary spaceships to Mars, Venus, and beyond.

In the National Launch Vehicle Program, NASA is progressively replacing its original space vehicles, which stem chiefly from Department of Defense programs, with vehicles built exclusively for the practical utilization and conquest of space. During the period, the Thor-Able, Juno II, and the Atlas-Able boosters were phased out as the Scout, Delta, and Atlas-Agena B launch vehicles advanced to operational status. Existing and planned NASA launch vehicles are depicted in Table 2, "NASA Launch Vehicles—June 30, 1961." NASA employs the Redstone and single Atlas shown in the table principally as boosters for the Mercury manned capsule.

Table 2.—NASA Launch Vehicles, June 30, 1961

Vehicle	Stages	Propellant	Thrust (in Thousands of pounds)	Maximum diameter (feet)	Height less spacecraft (feet)	Payload (lbs) 345 mile orbit	Payload (lbs) Escape	Payload (lbs) Planetary	First NASA launch
Redstone	1. Redstone	LOX/ALCH [1]	78	5.9	83	Ballistic			1960.
Scout	1. Algol (Aerojet Senior)	Solid	98	3.3	65	150			July 1, 1960.
	2. Castor (XN-33-20)	Solid	48						
	3. Antares (X-254)	Solid	13.6						
	4. Altair (X-248)	Solid	2.8						
Delta	1. Thor (DM-19)	LOX/RP [2]	150	8.8	77	500	60		May 13, 1960.
	2. AJ10-118 (Improved AJ10-42)	WIFNA/UDMH [3]	7.7						
	3. Altair (X-248)	Solid	2.8						
Thor-Agena B	1. Thor	LOX/RP [2]	165	8	80	1,600			1962.
	2. Agena B	IRFNA/UDMH [4]	16						
Atlas D	1. Atlas D	LOX/RP [2]	367	10	72	2,700			1960.
Atlas-Agena B	1. Atlas D	LOX/RP [2]	367	10	98	5,000	750	400	1961.
	2. Atlas D Sustainer	LOX/RP [2]	80						
	3. Agena B	IRFNA/UDMH [4]	16						
Centaur	1. Atlas D	LOX/RP [2]	367	10	105	8,500	2,300	1,300	1962.
	2. Atlas D Sustainer	LOX/RP [2]	80						
	3. Centaur	LOX/H_2 [5]	30						
Saturn C-1	1. S-1 (8 Cluster H-1)	LOX/RP [2]	1,500	21.6	125	20,000			1 stage, 1961.
	2. S-IV (6 Cluster RL10A-3)	LOX/H_2 [5]	90						2 stage, 1963.
Advanced Saturn	1. Cluster F-1	LOX/RP [2]				200,000	85,000	60,000	
	2. Cluster J-2	LOX/H_2 [5]							
	3. One J-2	LOX/H_2 [5]							
Nova			12,000-20,000	50	280	350,000	150,000	100,000	

[1] Liquid Oxygen/Alcohol.
[2] Liquid Oxygen/Kerosene-like Hydrocarbon.
[3] White Fuming Nitric Acid/Unsymmetrical Dimethylhydrazine.
[4] Inhibited Red Fuming Nitric Acid/Unsymmetrical Dimethylhydrazine.
[5] Liquid Oxygen/Liquid Hydrogen.

Scout

Payload Capability To Be Increased

In December 1960, NASA began to incorporate into Scout's third and fourth stages improved solid propellants originating from the Department of Defense Minuteman and Polaris programs. This modification which requires relatively minor design changes will increase Scout's payload capacity about 40 percent.

Developmental Tests Continued

During the period, NASA conducted the second through the fifth in a series of eight Scout developmental flight tests. In the tests (which took place October 4, 1960; December 4, 1960; February 16, 1961; and June 30, 1961, at Wallops Station, Va.) NASA programed vehicles for both ballistic and orbital trajectories. Although the primary intent of these launchings is to gather data on Scout performance, Scout usually carried a scientific payload. On February 16, Scout orbited Explorer IX, the first satellite launched from Wallops Station (and the first satellite launched by a United States all-solid-fuel vehicle). Additional data on Scout satellite launchings appear in chapter 4.

Additional Procurement

On May 8, 1961, NASA awarded a letter contract for 14 Scout vehicles to Astronautics Division, Ling-Temco-Vought Corp., Dallas, Tex. Eight are for NASA programs and six for Department of Defense. This procurement is in addition to the eight vehicles in the Scout developmental series. NASA plans to use Scout for small satellites, atmosphere-entry tests, and other scientific experiments.

Delta

The Delta launch vehicle orbited the TIROS II weather satellite on November 23, 1960, and the Explorer X satellite (for gathering data on magnetic fields) on March 25, 1961. Explorer X marked the third consecutive success of Delta, which earlier (August 12, 1960) had orbited the Echo I communications satellite.

NASA's original contract with Douglas Aircraft Corp., Santa Monica, Calif., was for design, development, fabrication, and launch of 12 Deltas.

Thor-Agena B and Atlas-Agena B

The Thor-Agena B and Atlas-Agena B boosters are U.S. Air Force developments which NASA is adapting to civilian space experiments.

NASA plans to employ Thor-Agena B in launching communications, meteorological, and scientific satellites requiring polar orbits. Units for assembly into NASA's first Thor-Agena B launch vehicle are scheduled for delivery at Point Arguello, Calif., in early 1962. The vehicle will launch Echo A–12, the reinforced and enlarged successor to the Echo I communications satellite. (See ch. 9.)

Atlas-Agena B was originally designated for use in NASA's unmanned lunar program and in firing communications, meteorological, and scientific satellites into east-west orbits. Because of delays in Centaur development (see below), NASA intends to employ Atlas-Agena B instead of Centaur for sending an instrumented spacecraft, designated Mariner R, to the vicinity of Venus in 1962. (Mariner R will weigh only about half as much as the spacecraft originally planned for launch by the more powerful Atlas-Centaur.)

The Agena B contractor, Lockheed Aircraft Corp. Santa Cruz, Calif., delivered the first NASA Agena to Cape Canaveral, Fla., on June 30, 1961. This rocket will become the upper stage of an Atlas-Agena B scheduled to launch Ranger I in August 1961. Ranger I is intended to test techniques and equipment for lunar and interplanetary programs.

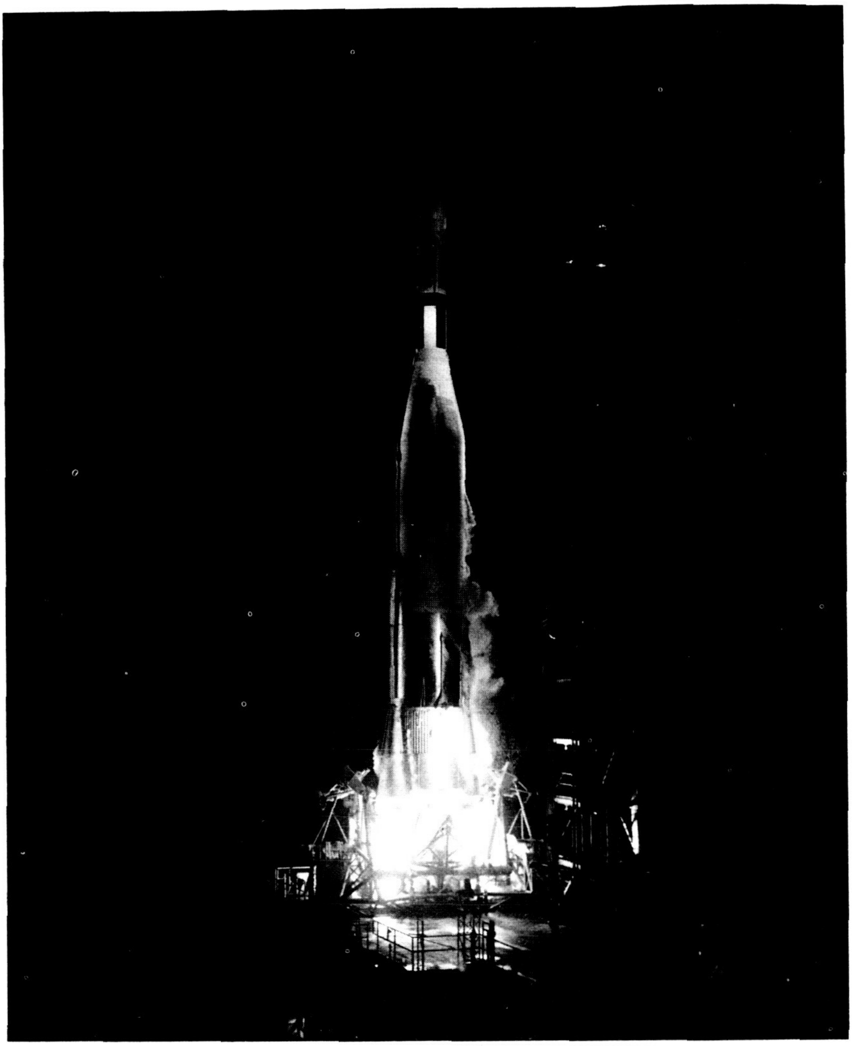
Atlas-Centaur

NASA plans to use Atlas-Centaur to launch heavy unmanned instrumented probes to the moon, Mars, and Venus. The development program is concentrated largely upon engines for the upper stage—the first in the United States which will burn high-energy liquid hydrogen and liquid oxygen (LOX) instead of refined kerosene and LOX.

Serious difficulties encountered in the development program have delayed the first Centaur research and development flight (originally planned for January 1961) until 1962. This delay precluded Centaur's availability for the first Venus launch.

The engine ignition system was redesigned, and the contractor test fired the engines 515 times, accumulating 47,476 seconds of trouble-free operation by June 30, 1961.

Two engines were shipped to the Atlas-Centaur vehicle contractor, Convair Astronautics Division of General Dynamics Corp., San Diego, Calif., for assembly into the upper stage of Atlas-Centaur. After a preliminary static firing, Convair will ship the stage to Cape Canaveral, where it will be mated to an Atlas for flight test in 1962.

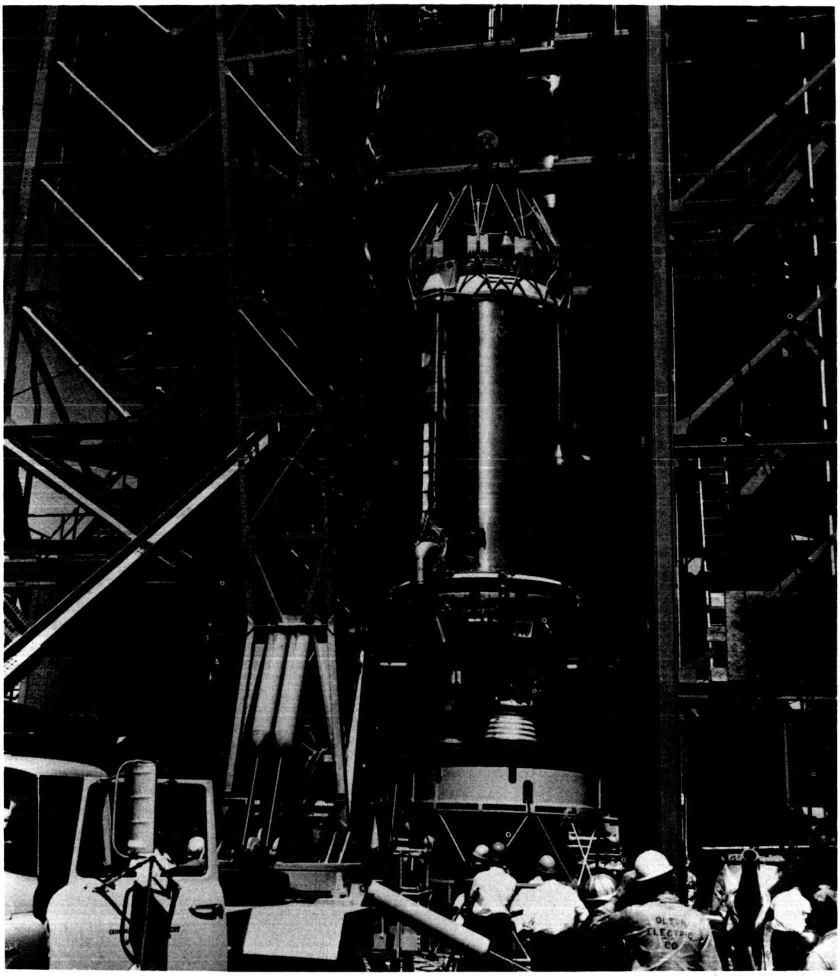


Atlas-Agena B launches Ranger I at Cape Canaveral on August 23, 1961 (after the report period). A malfunction in the Agena B prevented the Ranger from attaining the required orbit. The two-stage Atlas-Agena B is capable of launching 750-pound hard-landing lunar probes and 5,800-pound earth satellites

Saturn C–1

Modifications

During the period, NASA substantially modified the 1.5-million-pound-thrust Saturn C–1 to meet requirements for orbital flight of the Apollo manned spacecraft within accelerated time schedules. Fins were added to the first stage to improve flight stability and control. Six 15,000-pound-thrust RL–10A–3 engines (also used in the Atlas-



Twin-engined Centaur, second stage of the Atlas-Centaur vehicle, rises into position in its gantry at Cape Canaveral. Atlas-Centaur will launch interplanetary probes in 1962 and instrumented packages for soft landings on the moon in 1963

Centaur upper stage) were substituted for the four 17,500-pound-thrust RL–10B engines originally intended for the second stage.

The substitution offers certain advantages. The modification gives the second stage an "engine-out capability"—if one engine fails to ignite, the others will consume its propellant with virtually no loss in vehicle performance. The increased power of the second stage—from 70,000 to 90,000 pounds of thrust—and a planned addition to propellant capacity of the first stage have given these two stages the capability of orbiting a larger payload than the original configuration. The Saturn C–1 has therefore been redesigned as a two-stage instead of a three-stage vehicle for its primary Apollo earth-orbit mission.

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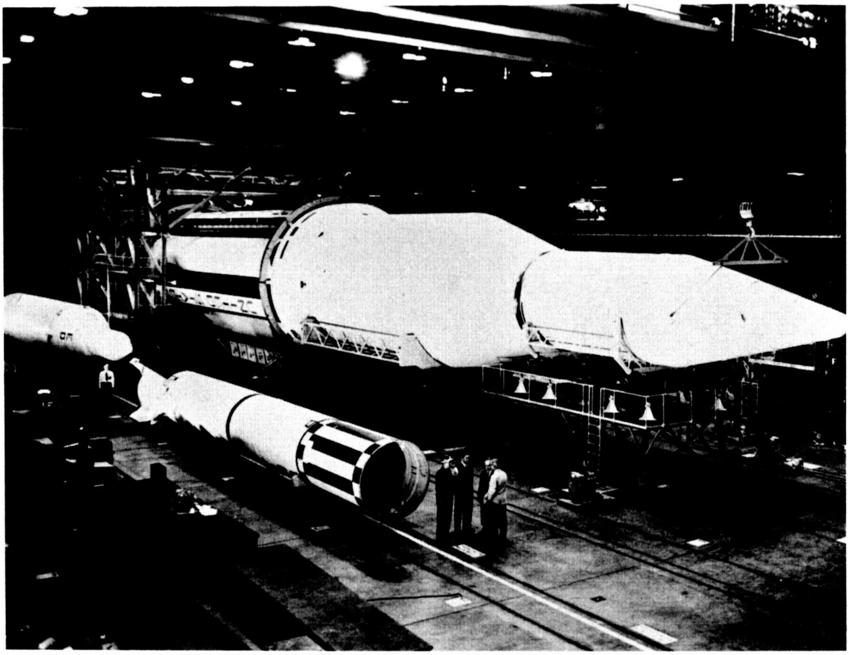


Saturn C–I rocket vehicle appears in its three-stage flight configuration (background) at Marshall Space Flight Center. The 180-foot vehicle is shown with the S–I first stage and dummy second and third stages

S–I Ground Tests Completed

In static tests at Marshall Space Flight Center, Huntsville, Ala., NASA fired the S–I (designation for Saturn C–1 first stage) for 30, 44, and 111 seconds, respectively. In the last test (May 1961), S–I generated the planned 1,315,000 pounds of thrust.

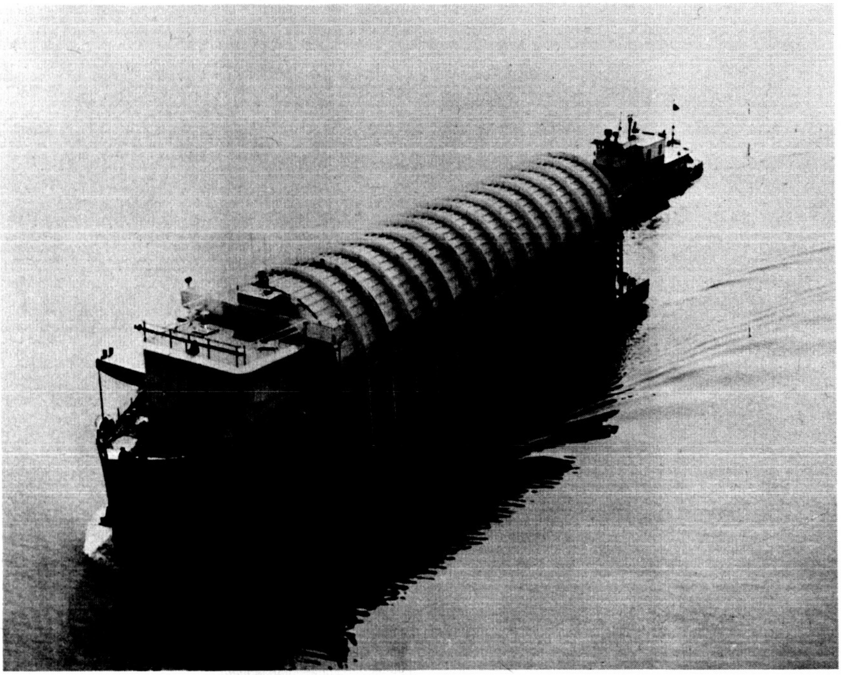
The first research and development flight test of S–I is scheduled at Cape Canaveral, Fla., in October 1961.[1] Dummy upper stages will be mounted on the first four Saturn flight vehicles.

S–I Transport Route Blocked

On June 2, 1961, a lock wall collapsed at Wheeler Dam on the Tennessee River, stranding the Saturn transport barge *Palaemon* upstream and preventing it from carrying the booster from Marshall Space Flight Center to Cape Canaveral.

The Tennessee Valley Authority, the U.S. Army Corps of Engineers, Marshall Space Flight Center, and the Navy developed an emergency plan to transport the booster from Marshall to the dam in the *Palaemon*, portage it around the dam, and reload it aboard the surplus

[1] The Saturn flight was satisfactory. S–I operated as intended.



Saturn first stage starts its trip to Cape Canaveral, Fla., on the barge "Palaemon." At the Cape, the 1.5-million-pound booster will be tested and readied for launching late in 1961

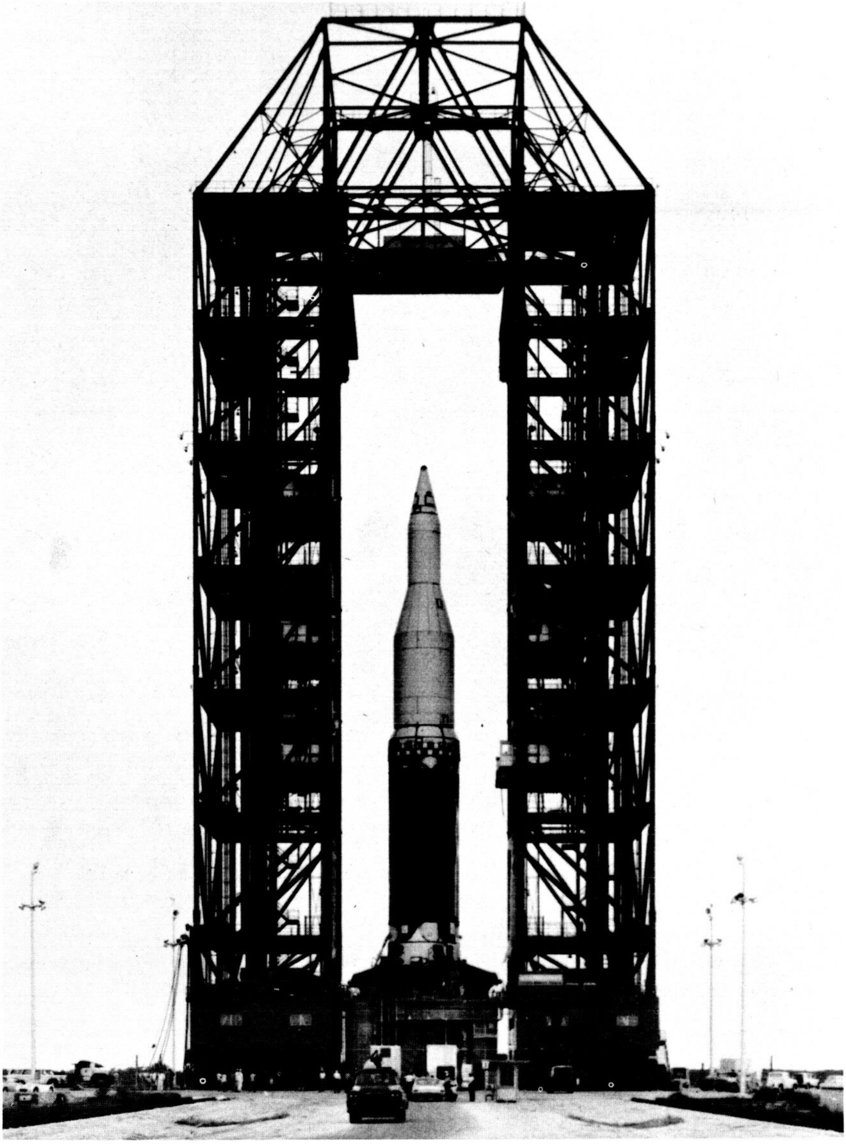
Navy barge *Compromise* (YFNB–23) on the downstream side, for the voyage to Cape Canaveral. The TVA constructed loading ramps on both sides of the dam and, with the assistance of the Corps of Engineers, a 1½-mile connecting road.[2] The water route from Marshall to Cape Canaveral is via the Tennessee, Ohio, and Mississippi Rivers, Gulf of Mexico, Atlantic Ocean, and the Indian and Banana Rivers.

Complete C–1 Test Scheduled for 1963

Plans call for the S–IV (Saturn C–1 second stage) to be ready for flight tests in 1963. Research and development flights of the complete Saturn C–1 will then begin—including some launches with boiler-plate (stripped down) versions of the Apollo manned spacecraft.

Primary goal of the Saturn C–1 program is to reach operational status by 1964, in time for the scheduled launch into orbit of the Apollo manned capsule. The Apollo orbital mission is the first of three major steps in the United States plan to land men on the moon and return them safely to earth.

[2] The S–I reached Cape Canaveral without major incident on August 15, and was erected on the launch stand August 20.



Saturn stands in gantry at Cape Canaveral as preparations are made for first test launches with 1.5-million-pound-thrust first stage and dummy upper stages

Advanced Saturn

Further delineation of requirements of the Apollo manned capsule made it apparent that the planned C–2 version of Advanced Saturn (a 1.5-million-pound-thrust first stage, an 800,000-pound-thrust second stage, and a 90,000-pound-thrust third stage) would be unable to launch a payload the size of the Apollo circumlunar spacecraft. Flight around the moon is the second step in NASA's manned lunar program.

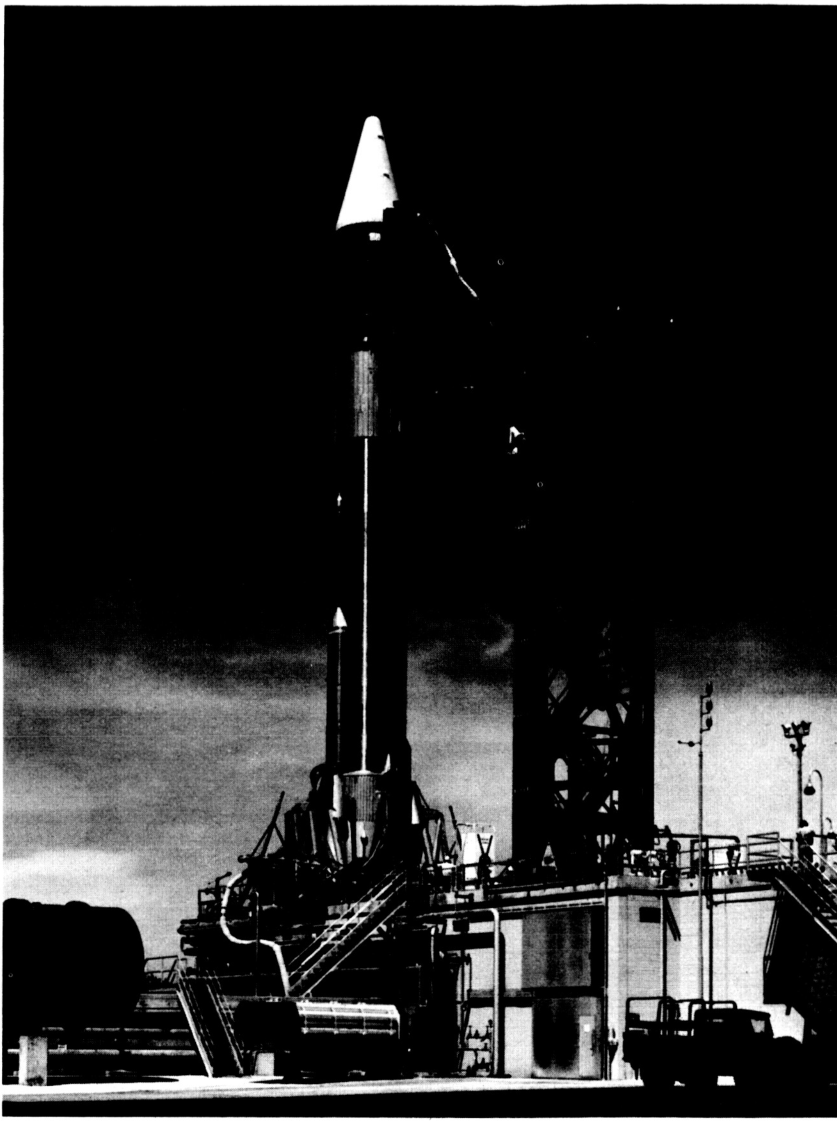
NASA is planning an Advanced Saturn which is to replace the C–2 design. It would be made up of a cluster of huge F–1 engines, each generating 1.5-million pounds of thrust. Upper stages would be propelled by 200,000-pound-thrust, liquid hydrogen-liquid oxygen J–2 engines.

Nova

Nova, a conceptual vehicle, is the most powerful under NASA consideration. It would have a 12- to 20-million-pound-thrust first stage, consisting of a cluster of F–1 engines or an immense solid rocket. Its upper stages would be clustered rocket engines fueled by high-energy liquid hydrogen-LOX, with, perhaps, one nuclear-rocket upper stage.

Primary roles will be to direct launch the Apollo spacecraft on its lunar-landing goal and to drive huge spaceships toward other planets.

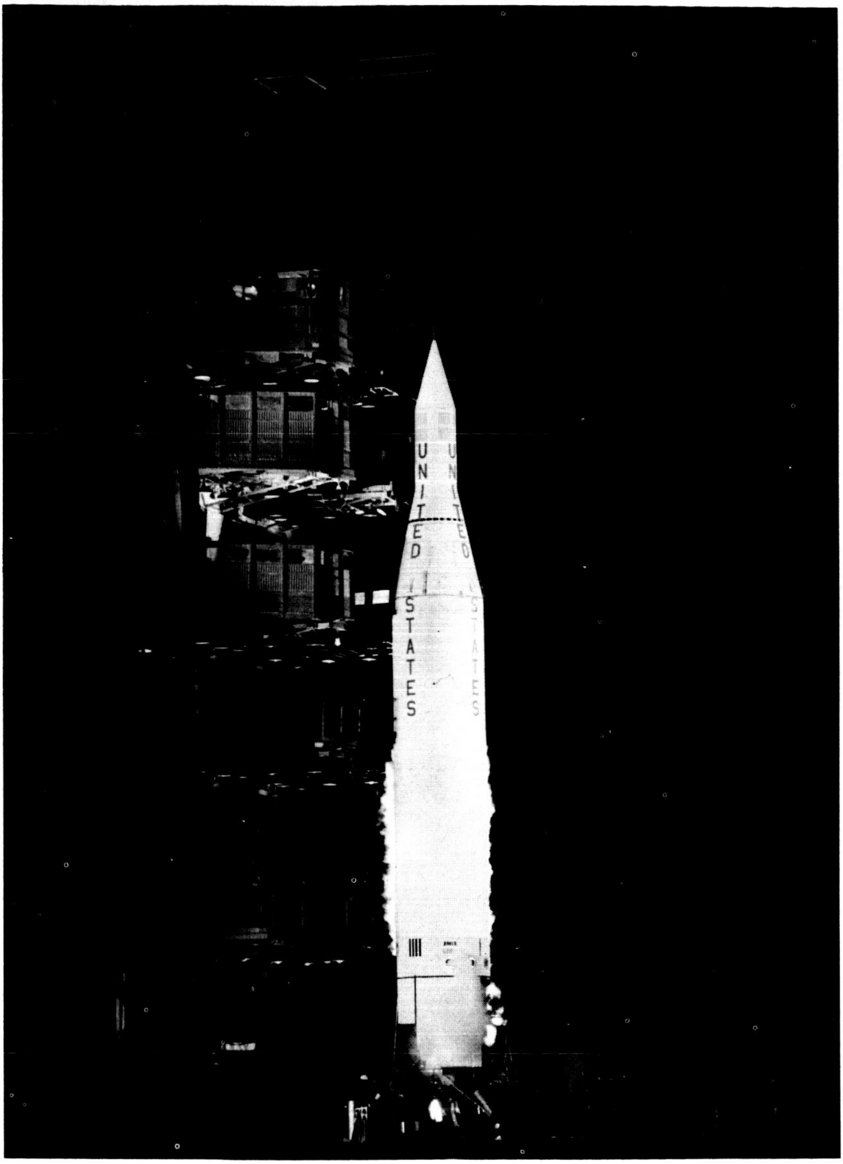
Direct launch is in contrast to another method in which smaller launch vehicles would orbit separately a fully-fueled rocket stage and the Apollo spacecraft with auxiliary propulsion. The astronauts aboard Apollo would guide it toward a junction with the rocket stage, a maneuver termed "orbital rendezvous." When the joined Apollo and rocket are at the optimum point in orbit, the rocket would be fired, launching Apollo toward the moon.



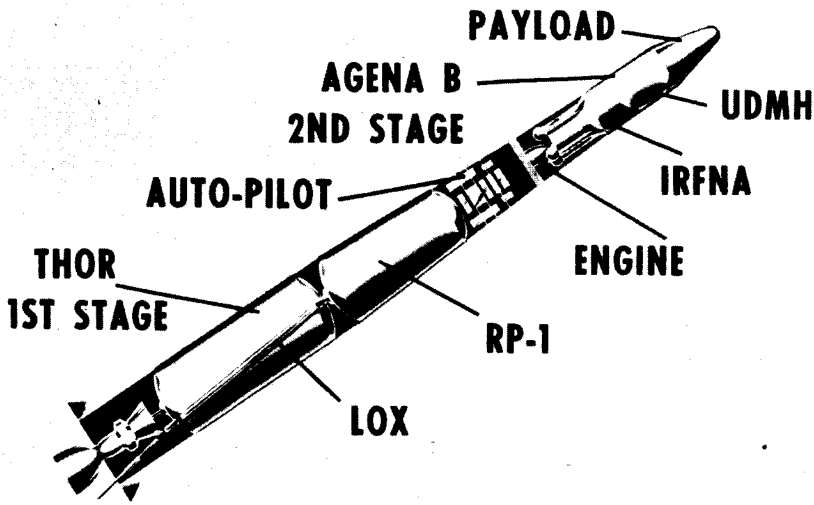
Atlas-Centaur, 107-feet high, will be the first United States launch vehicle to employ a high-energy upper stage, using liquid hydrogen-liquid oxygen (LOX) instead of the conventional combination of kerosene and LOX. Capability: 8,500-pound earth satellites, 2,500-pound lunar probes, and 1,450-pound Mars and Venus experiments

Saturn first stage completes final static firing at Marshall Space Flight Center on February 14, 1961. The booster, which will be used in the U.S. manned space flight program, will develop 1.5-million pounds of thrust

Four-stage Scout boosts Explorer XIII micrometeoroid satellite into orbit, August 25, 1961 (after the report period). Scout is an all-solid fuel vehicle of considerable versatility



Juno II, a U.S. Army-developed launch vehicle which orbited Explorer XI, stands in its gantry at Cape Canaveral during a static firing



Thor-Agena B is scheduled for delivery to NASA in early 1962. The Thor booster provides 165,000 pounds thrust, the upper stage Agena B, 15,000 pounds.

Propulsion and Power Generation

Research Stresses Three Basic Systems

NASA is centering its propulsion research on rocket engines of three basic types: chemical—both liquid and solid; electrical; and nuclear.

Liquid-propellant engines continue to dominate the current NASA launch-vehicle family. (NASA currently has one all-solid-propellant launch vehicle—the four-stage Scout.) Looking further to the future, the Agency is devoting increased effort to electrical and nuclear systems having good promise for use with interplanetary spacecraft now being designed.

Liquid Propulsion

Most liquid-propellant engines employed today burn kerosene and liquid oxygen (LOX), a propellant-oxidizer combination having relatively low energy. The growing need for more powerful and efficient chemical engines has spurred research into high-energy combinations, such as liquid hydrogen and LOX. Work on such engines for upper stages is being particularly emphasized. They will greatly increase our overall launch-vehicle capabilities since they will be able to lift heavier payloads and perform higher energy space missions than present engines.

H–1 Hydrocarbon-Oxygen Engine

The H–1 engine—fueled with a refined form of kerosene called RP–1—is being designed to attain a high level of reliability and performance (thrust raised from 165,000 pounds in the initial design to 188,000 pounds) for use in a cluster of eight in the first-stage Saturn booster. The required increase in thrust puts undue strain on some components (designed to operate at the original level) and appreciably lowers the safety margin for others. Work is therefore in progress to simplify the engine system by integrating functions—that is, having one component perform more than one function—and some of the more serious operating problems are being eliminated through redesign. The turbopump, for example, has now been rebuilt with stronger bearings, gears, and pumps, permitting safe operation at the higher power output.

In static tests (ground "tiedown" firings on special stands, simulating conditions of actual flight) at the 188,000-pound-thrust level by the contractor (Rocketdyne Division of North American Aviation, Inc., Canoga Park, Calif.), combustion became rough on several occasions, burning the thrust chamber beyond repair. The injector was modified to stabilize combustion, and the burnout problem was eliminated.

In November 1960, after exhaustive tests to qualify the H–1 engine for flight, the contractor made initial delivery to the Marshall Space Flight Center for clustered assembly in the Saturn first-stage booster.

H–1 Engine Cluster Tested.—In static tests of eight-engine H–1 clusters at Marshall, LOX leaked through cracks caused by unrelieved stresses in the dome of the thrust chamber. An improved fabrication technique has been adopted, and the defect has not recurred.

To determine whether the cluster might be reused after launching and separation from the Saturn vehicle, an engine was fired and then immersed in salt water. The unit was later removed, carefully examined and checked out, and refired. Results were promising; there was apparently little or no ill effect from the salt water.

J–2 Hydrogen-Oxygen Engine

Development of the single-chamber J–2, a 200,000-pound-thrust liquid hydrogen-LOX engine (for clustered use in the second stage of the advanced Saturn), continued at the Rocketdyne Division of North American Aviation, Inc., Canoga Park, Calif. (Development of the J–2 began in September 1960.) Progress was satisfactory, although some difficulties were encountered in the turbopump and thrust chamber, requiring changes to be made in the initial design. First engine deliveries to NASA are scheduled for November 1962.

Static tests of uncooled J–2 thrust chambers with hydrogen propellant in both the gaseous and liquid state disclosed no serious operational problems. Beginning in April 1961, on a modified stand at the contractor's Propulsion Field Laboratory, a series of firings with many thrust chambers, both cooled and uncooled, was carried out, starting at 4 seconds and gradually approaching the full rated duration.

F–1 Engine

The F–1 is a 1.5-million-pound-thrust liquid oxygen-hydrocarbon fuel engine.

Thrust Chamber Development.—During the report period, three problems, two of which caused major damage to hardware and test facilities, were solved. Rough combustion—one of the problems—was overcome by developing injectors with stable operating characteristics and by adding baffle plates to the injectors.

The second problem, inadequate cooling, was resolved by redesigning the injector hole pattern and by using copper rings in the construction of the injector.

The third problem was encountered in the manufacture of the thrust chambers. The solution in this case was to use extreme care in fabricating the bundles of high temperature alloy tubes used in the regeneratively cooled thrust chambers.

Thrust Chamber Tested.—Sixty-seven main stage tests and two ignition tests of the engine's thrust chamber had been conducted before testing of the complete engine. These main stage and ignition tests began in November 1960.

On February 10, 1961, the F-1 chamber registered a thrust of 1,556,000 pounds for two seconds. On April 6, 1,640,000 pounds of thrust was attained for 13 seconds.

Test First Complete Engine Successfully.—On June 13, Rocketdyne engineers static-tested a complete F-1 engine for the first time at Edwards Air Force Base, Calif. The engine operated for 350 milliseconds, recording a thrust of 1,019,000 pounds. Its performance was smooth and reliable.

On June 16, the engine was tested for 5.5 seconds at thrust levels just over 1 million pounds. Again, it operated as planned.

Test Tempo To Increase.—Full-scale static firings will increase in tempo and duration during the coming months. More than 300 engine tests are planned for next year. Preliminary flight-rating tests are scheduled to begin in December 1962 and end in March 1963.

Advanced Liquid-Propellant Technology

Storage of Propellants in Space Environment.—In a continuation of studies of space environmental problems under NASA contract, the Arthur D. Little Co., Cambridge, Mass., has been investigating propellant storage in space. Using various laboratory and experimental techniques, liquid hydrogen and LOX were exposed to the various hazards found in space, such as ionizing cosmic rays, thermal radiation (heat) from the sun, and micrometeoroids. The conclusion was reached that this propellant combination will not suffer from long-term exposure to ionizing forms of radiation, but shielding the cryogenic (very cold) liquid hydrogen from the heat of the sun may be a major engineering problem.

In related work, various techniques were used to gain data on the density, mass, and velocity of micrometeoroids.

Plug Nozzle Rocket Engine.—Further studies were made of the "plug nozzle" concept for rocket engines (described in ch. 11 of the third, and ch. 8 of the fourth, NASA semiannual reports to Congress).

F–I engine in static test at Flight Research Center, Edwards, Calif.

An integrated plug nozzle engine with segmented combustors was operated with and without cooling. Results were extremely promising: the engine produced the 50,000 pounds of thrust called for in the design, and the direction of thrust was successfully varied by changing the pressure in the individual segments. The findings were in close agreement with previous calculations, and proved the feasibility of the design concept.

During the period, the contractor also tested a system of cooling the combustion chamber segments of the engine by circulating a portion of the cryogenic propellant as a "coolant." The tests demonstrated that the heat of combustion can be absorbed without difficulty when this method is employed.

The investigation of the plug nozzle engine was conducted, under NASA contract, by the General Electric Co.'s Malta test station, Schenectady, N.Y. The project has been completed, and a final report has been issued.

Solid Propulsion

NASA conducted an extensive solid-propulsion technology research program to improve large and small engine performance, reliability, and versatility. Much of the work was centered on the four-stage Scout and relatively small sounding rockets such as Iris and Arcon. However, studies were also in progress on much larger solid-propellant engines for eventual use in first-stage launch vehicle.

Arcon Sounding Rockets.—Two Arcon rockets which had been stored at 120° F. for 6 months and 1 year, respectively, were removed, studied for possible deterioration, and static-fired. (The high-temperature storage speeds up the aging process fourfold; thus 6 months of storage at 120° F. is equivalent to 2 years at normal room temperatures of 70° F. This method makes it possible to assess storage life quickly.)

The engine stored for 1 year performed within specifications. The 6-month unit, however, burned out the insulation of the internal chamber after 28 seconds of operation (normal burning time: 34 seconds). Analysis indicated that the burnout probably resulted from a flaw in the insulation which may have been aggravated by storage.

Iris Sounding Rocket Development Completed.—The development program for Iris was completed. The Iris rocket, developed by Atlantic Research Corp., Springfield, Va., is designed to propel a 100-pound payload to an altitude of 185 miles. The rocket is approximately 13 feet long, 1 foot in diameter, weighs 1,140 pounds, and uses the same solid propellant as Arcon. When a stabilizing fin section and the 100-pound payload are attached, the vehicle totals 1,290 pounds and is 20 feet long. Launched from a tower, the rocket will receive extra initial thrust from a small, clustered booster.

Of three flight tests (July and October 1960 and January 1961), two met all objectives. In the third test, the rocket functioned properly until it had burned for 53 seconds when the vehicle became unstable and began to tumble. Analyses indicate that a leak may have occurred in the rocket engine just before burnout. The pressure-monitoring port on the nozzle end is suspect, and extra insulation may be applied at this point in future vehicles.

Archer Advanced-Design Sounding Rocket.—The Atlantic Research Corp. static-fired five Archer rocket engines; three were completely successful. Seven inches in diameter and weighing 200 pounds, Archer embodies several design improvements which could be used to enhance performance of sounding rockets such as Iris. The nozzle of the improved engine is completely lined with graphite to minimize erosion and thrust misalinement. The engine has a new high-burning rate, an increased-energy propellant, a propellant support system capable of withstanding high accelerations, and improved chamber insulation to decrease the inert weight. Although this engine was designed solely to test several advanced features, its overall performance characteristics may warrant the building of a new vehicle capable of satisfying the sounding rocket requirements of several Government agencies.

Solid-Propellant Rocket Technology

Studies of high-performance rockets were continued during the period. Typical are the following:

"Nozzleless" Rocket.—Following the four successful static firings of a nozzleless rocket reported in the last period, an analytical study was completed by Grand Central Rocket Co., Redlands, Calif., to conclude its contract. This analytical phase indicated that the nozzleless concept offers distinct advantages in performance and cost for small sounding rocket payloads. One basic disadvantage is the potential thrust misalinement caused by using the propellant opening as a nozzle.

Multilayered Rocket Engine.—The Allegany Ballistics Laboratory, Cumberland, Md., completed five static firings of this experimental, highly efficient, solid-fuel engine. The first four were partially successful; the last, completely so. The 600-pound gross weight engine consisted of more than 94 percent solid propellant by weight and a bare minimum of inert structural components. The pressure and thrust curves exhibited the predicted pattern as the various layers of propellants were consumed. A 10-month contract extension was granted for further design improvement and about six more firings are planned.

Nozzle Cooled by Liquid Metal.—Under a contract with NASA, the Rocketdyne Division of North American Aviation investigated the possibility of producing an efficient, lightweight nozzle system by spraying liquid lithium onto a very thin high-temperature-resistant (refractory) metal cone. Although analysis indicated that such a nozzle system is possible, the experimental portion of the program has been delayed by problems in welding, brazing, and riveting. A molybdenum alloy nozzle assembly (for 3,000 pounds of thrust) accepted for firing tests cracked after it was attached to the test stand. The mechanical properties of these refractory metals must be improved before this nozzle design can be utilized.

Steering and Velocity Control Studies

Fluid Injection Steering.—The Naval Ordnance Test Station, Inyokern, Calif., continued studying the possibility of steering a rocket by injecting gases or liquids into the nozzle exit cone.

One test with the 3,000-pound-thrust fourth stage of Scout indicated that an inert fluid injected at several points in the exhaust nozzle cone can generate substantial steering forces. Two more firings are planned to test another fluid and a larger nozzle cone. This system may be applied to very large solid boosters as well as small vehicles.

Steering Package Concept.—The Allison Division of General Motors, Inc., Indianapolis, Ind., and Vickers, Inc., Detroit, Mich., continued parallel research on a package of separate solid rocket motors to steer vehicle stages.

The initial program of the Allison system (four solid rockets, rotating independently and controlled by the guidance system) was completed. In final tests the four-rocket packages worked well, system response rates were good, and no malfunctions occurred during burning. Further study is planned.

The Vickers system controls vehicle direction and roll by means of a single solid-propellant gas generator that exhausts through valves to a series of fixed nozzles. In early tests, the gas from the central generator overheated the control valves. Later, when the gas temperatures were lowered, the valves passed preliminary tests. Problems in design of the lightweight Fiberglas chamber for the gas generator were solved, and the packaged system—generator, valves, and fixed nozzles—was readied for testing.

Acoustic Control of Burning Rate

Further tests of sonic (sound-wave) control of solid propellants were conducted by Acoustica Associates, Inc., Los Angeles, Calif., under NASA contract. Research indicated that the burning rate may be acoustically modified at fairly high sonic-energy levels. Further work will concentrate on demonstrating feasibility and learning more about the mechanism that controls the burning rate.

High-Temperature Nozzle Materials

Under NASA contract, the Arde-Portland Corp., Newark, N.J., completed a study of materials capable of resisting very high temperatures. During the period, the contractor tested pyrolytic graphite, columbium, tantalum carbides, two-phase systems of tungsten plus a carbide, and aluminum infiltrated refractory carbide. All materials were subjected to combustion pressures of 500 to 1,000 p.s.i and temperatures up to 6,500° F.—conditions as severe as any expected to be encountered in solid rockets today. Several of the materials seemed to have qualities worthy of consideration for future use in space propulsion motors.

Solid Rockets as First Stages of Launch Vehicles

Feasibility Studies Completed.—In March, NASA contractors completed feasibility studies of solid rockets and rocket clusters with thrusts of 3 to 15 million pounds. The 6-month, $216,000 study began in September 1960. Contractors included the Aerojet General Corp., Sacramento, Calif.; Grand Central Rocket Co. (now Lockheed Propulsion Co.), Redlands, Calif.; and Thiokol Chemical Co., Huntsville, Ala.

Design studies were based upon two vehicle concepts: one to place a 40,000-pound satellite in an earth orbit, the other to power a 125,000-pound spacecraft on lunar and interplanetary missions. Both vehicles would employ solid-propellant first stages and liquid hydrogen-liquid oxygen upper stages.

The detailed studies considered engine and cluster designs, development programs, and the logistics of fabricating and handling such large engines. The conclusion, which agrees with that reached by other investigators, is that currently available propellants, construction methods, and thrust vector control systems can be combined to perform the required missions, in some cases at substantial savings. Problems associated with scale-up may be encountered, but analysis indicates that they can be solved.

The proposed engines were all of conservative, relatively simple design. Almost all thrust-vectoring steering systems used jet vanes or fluid injection to permit rocket engines to be developed independently of the vectoring systems; this method will make it easier to separate potential problems and thus to minimize costs. Contractors estimated that development would require from 2 to 3 years, depending on engine size; clustering tests will take longer, and some new facilities will be required.

Segmented and Tapered Large Solid Rockets.—The United Technology Corp., Sunnyvale, Calif., completed tests of three solid segmented rockets, each made in three separate sections weighing about 1,000 pounds each. Joined at the firing site, the complete engines were 38 inches in diameter (tapered), 6 feet long, and weighed 3,000 pounds. In static-firing tests, each of the three rockets delivered about 15,000 pounds of thrust for 50 seconds.

Two types of segment joints were evaluated, one utilizing shear pins, the other recessed bolts; each functioned properly. The chambers were unaffected by firing, and the nozzles showed very slight erosion; the engines are reusable.

The tests indicate that it may be practical to build motors in segments for easier handling and shipment—by truck, railroad cars, or other means of transport unable to carry complete units weighing, perhaps, several hundred thousand pounds.

The purpose of the tapered shape of the segments (3° taper overall) is to generate the same gas dynamic conditions near the forward end of the motor that exist at the aft end, eliminating any variation in burning rate along the length. Short test motors should burn the same as long, full-scale motors. For this reason tapering may minimize the number of full-scale tests required.

Under a new, cost-sharing, $1.8 million contract with NASA, United Technology undertook the design of a much larger engine and began fabrication of its chamber components. The new engine will weigh more than 35 tons and deliver about 250,000 pounds of thrust for 1 minute. More than 27 feet long, it will have a central segment and two end sections. It can be enlarged by adding extra segments and a larger nozzle. Firing is planned for August 1961. (This test was carried out with essentially all goals attained.)

Multimillion-Pound-Thrust Launch Vehicles

In March 1961, NASA awarded three parallel contracts for six-month studies of advanced launch vehicles having first stages with 6 to 12 million pounds of thrust. Contractors are: Convair Division, General Dynamics Corp., San Diego, Calif. ($130,017); Georgia Division, Lockheed Aircraft Corp., Marietta, Ga. ($136,743); and North American Aviation, Inc., Los Angeles, Calif. ($160,041).

The contracts called for investigating (1) the role of nuclear propulsion; (2) recovery of large first-stage rockets; (3) comparison of pressure-fed and pump-fed systems; (4) employment of rocket engines fueled by liquid hydrogen and LOX instead of kerosene (RP–1) and LOX; and (5) development of dual-thrust first stages having either liquid- and solid-propellant engines or liquid- and nuclear-powered engines.

Nuclear Propulsion

The nuclear-rocket engine program (Project Rover) has emerged as a major phase of the national space effort. Analysis has indicated that the technology being developed in the Kiwi reactor and NERVA nuclear-rocket engine work now in progress could lead to a great improvement in payload capability and maneuverability when used, for example, as the upper stage of an Advanced Saturn.

The nuclear-rocket engine program is completely integrated. It involves the reactor, the engine, the test-flight vehicle, and test facilities development. The program is jointly supported by NASA and AEC.

AEC Ground-Tests Kiwi-A–3

In the third experiment of Project Rover a test reactor designated Kiwi-A–3 was successfully ground-tested by its designer, the Los Alamos Scientific Laboratory (LASL) at AEC's Nevada Test Site on October 19, 1960.

Like Kiwi-A-Prime,[1] the second experiment in the series, the reactor used hydrogen gas under high pressure as the "propellant," but contained modifications and design improvements over its predecessor. The test run lasted for 4 minutes 10 seconds at slightly above the design power and temperature.

Kiwi-B Reactor Test Planned

NASA and AEC announced on June 1, 1961, that the first of a series of Kiwi-B experimental reactors will be ground-tested in the fall at the AEC's Nevada Test Site. The tests will begin an accelerated testing phase in the joint NASA–AEC Project Rover nuclear rocket propulsion program.

The Kiwi-B reactor will provide further data for the development of a nuclear engine for rocket vehicle application (NERVA). The first experimental reactor system series, Kiwi-A, developed by the Los Alamos Scientific Laboratory and tested in 1959 and 1960, indicated the feasibility of applying such sources of power to rocket propulsion.

NERVA Contract To Be Negotiated.—On June 7, 1961, NASA and the AEC announced plans to negotiate with an industrial team—

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[1] Tested July 9, 1960. See NASA's Fourth Semiannual Report, pp. 106–107.

Aerojet-General Corp. and Westinghouse Electric Corp.—for a first-phase contract to develop the NERVA nuclear rocket engine. The 6-month contract calls for preliminary design of the NERVA engine, a development plan, and a schedule of costs and work.

Engine Contractor To Be Chosen

On November 1, 1960, NASA and AEC announced jointly a request for proposals from a number of manufacturers for research and development of an experimental nuclear rocket engine. The action, intended to speed development of the nuclear rocket by about 6 months, bypassed the customary feasibility design study requested several months earlier. The joint AEC–NASA Nuclear Propulsion Office (established on August 31, 1960) evaluated program requirements and concluded that Project Rover could be speeded by canceling the earlier request.

Nuclear Proposals

On February 2, 1961, the NASA–AEC Space Nuclear Propulsion Office, Germantown, Md., invited industry to submit proposals for participation in the nuclear-powered rocket engine program. The invitation delineated the engine contractor's initial role as assisting the Los Alamos Scientific Laboratory in conducting the reactor test program; in performing research and development in critical engine areas; in designing the first nuclear rocket engine; and in planning a development program. Interested companies were informed that deadline for receipt of proposals was 10 a.m., e.s.t., April 3, 1961.

Nuclear Rocket Engine Development Facility Study

In December 1960, the AEC–NASA Nuclear Propulsion Office chose an industrial team for contract negotiations to conduct a study of the requirements for a national nuclear rocket engine development facility. The new facility is needed because present test facilities at AEC's Nevada Test Site, Jackass Flats, Nev., are already fully committed to the development of nuclear reactors.

The proposal selected for initial negotiations was submitted by the Ralph M. Parsons Co., Pasadena, Calif., in association with the Thiokol Chemical Corp., Bristol, Pa., representing TALANT—a team consisting of Thiokol; the Allison Division of General Motors Corp.; the Linde Co., a division of Union Carbide Corp.; and the Nuclear Development Corp. of America. The proposal was one of 12 submitted after a briefing at AEC's Nevada Test Site on October 7, 1960, attended by representatives of 26 companies.

The 4-month study will furnish the following kinds of information required for planning the new establishment: Site considerations; number and type of test stands needed; control center; supporting facilities; buildings for assembling and disassembling reactors; requirements for water and electrical power; and construction costs and schedules.

SNAP–8 Design and Development

Design and development continued on SNAP–8 (Systems for Nuclear Auxiliary Power) a joint AEC–NASA project to develop a reactor and power conversion system to produce either 30 or 60 kilowatts of power.

The Aerojet-General Corp., Azusa, Calif., completed the design of the first experimental turbine and alternator for the 30-kilowatt power conversion system and commenced fabrication. Seal and pump tests were started both for the sodium potassium (primary) and the mercury (secondary) loops. The mercury pump operated satisfactorily at its rated speed of 20,000 r.p.m. Parts of the first low-power mercury vapor (secondary) loop were fabricated and the assembly drawing was released.

The SNAP–8 reactor and conversion system will be the first in the SNAP series powerful enough to generate electricity for ion jet propulsion and to furnish electricity for payload instrumentation.

SNAP–8 Trial Run.—The first trial run of the SNAP–8 boiler was made with boiling mercury at the AEC's Los Alamos Scientific Laboratory (LASL). A total of 60 kw. of heat was applied to the test section at a flow rate of 1,000 pounds per hour. Preliminary results indicated that the SNAP–8 boiler will be close to design specifications after minor changes.

Radiator tests continued; arrangements were made for Pratt & Whitney to measure radiating efficiency of coatings in the equipment already in use. Fabrication of components for the first experimental turbine was completed. Other major components were being fabricated and tested at LASL, and a low-power mercury vapor loop was being assembled.

High-Power Nuclear Turboelectric Systems

A number of unsolicited proposals relating to applied research on components for systems of higher power than SNAP–8 have been received and are undergoing evaluation.

Plum Brook Reactor Goes Critical

NASA's Plum Brook reactor, Lewis Research Center, Cleveland, Ohio, began operating on June 14, 1961. The reactor, completed in March, is designed for the study of such nuclear power system components as pumps, turbines, shielding, and propellant feed systems.

Over a period of several months, the output will be increased gradually to a maximum of 100 kilowatts; the reactor will then be shut down for a final inspection by NASA and the Atomic Energy Commission lasting about 30 days. After inspection, the reactor will be started up again with the long-range objective of reaching its full design power of 60 million watts.

Interior of the Plum Brook facility. The reactor core is 21 feet below the open hatch

After it achieves full power, the reactor will be used to investigate the effects of radiation on materials at extremely low temperatures and on sensitive electronic components. All these conditions may be encountered in the operation of nuclear-power systems for spacecraft.

The Plum Brook reactor was built by NASA engineers with the cooperation of AEC. Started in 1956, the $13 million facility now has a staff of over 150 engineers, physicists, and technicians.

Electric Propulsion

Three concepts of electric-propulsion engines are being explored under NASA research and development contracts. These comprise electrothermal (arc-jet), electrostatic (ion), and electromagnetic (plasma) engines, each of which will require a nuclear-electric power generating plant such as the SNAP–8 system.

1-kw. Electrothermal Engine.—This engine is being developed by the Plasmadyne Corp., Santa Ana, Calif., under a $2 million NASA contract awarded in September 1960. The contract calls for the development of an engine for use in spacecraft attitude-control and stabilization systems. In April 1961, $330,000 was added to the program for the design, development, and fabrication of a flight model. Flight testing is planned for late 1962, using a Scout vehicle.

30-kw. Electrothermal Engine.—Contracts to develop a laboratory model of a 30-kw., arc-jet engine for primary propulsion of spacecraft were awarded to the General Electric Co., Evendale, Ohio, and AVCO–RAD, Wilmington, Mass., in April 1960. The engine, about the size of a standard thermos bottle, will produce about one-half pound of thrust, and will have a continuous operating lifetime of 50 hours. It will require an auxiliary electric generating plant such as the SNAP–8 nuclear system now under development. When finally developed, the arc-jet engine system may be used as the main propulsion unit for raising satellites from low to higher altitudes, and for propulsion of spacecraft on earth ferry and lunar missions.

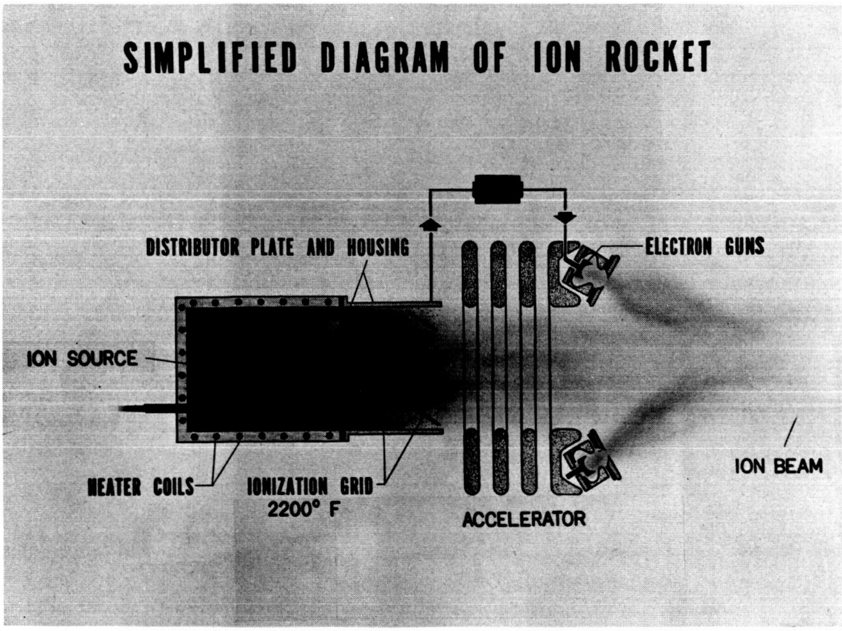
AVCO investigated a radiation-cooled, direct-current arc jet. Cryogenic propellants—hydrogen and helium—were studied, and it was concluded that considerable engineering development is necessary before such propellants can be adopted for arc-jet engines. However, work on the 30-kw., arc-jet engine improved electrode operating life by (1) increasing the direct current arc length, and (2) employing a new method to feed the propellant to the arc.

The General Electric Co. worked on a regeneratively cooled alternating current arc jet, seeking the optimum configuration and propellant. Such an engine would eliminate conversion equipment needed for direct current, arc-jet engines.

Electrostatic Engines

The Hughes Research Laboratory, Malibu, Calif., has a NASA contract to develop a laboratory model cesium ion engine with a thrust of 0.002 pound. Flyable models can be clustered to produce a total thrust of 0.01 pound. One experimental unit was built and tested in a vacuum tank equipped to measure the thrust. Laboratory tests of ion beam neutralization indicate that the Hughes neutralization system should be satisfactory. After full testing operation of the prototype, flight-engineered models of the millipound engine will be constructed and put through environmental tests.

In March 1961, NASA added $321,200 to an earlier $490,000 contract for the Hughes cesium-fueled ion engine, advancing the first flight test of an electric space propulsion system to October 1962. A mercury engine under development at the Lewis Research Center will be tested on the same flight.



Ion Rockets.—In January 1961, NASA selected the United Aircraft Corp. Research Laboratories, East Hartford, Conn., for negotiation of a $100,000 contract to study ion rockets as propulsion sources for interplanetary spacecraft. The contract specifies a 12-month study of 30-kilowatt to 1-megawatt ion rockets and of dual-thrust propulsion systems; that is, engines combining chemical and ion power.

Electromagnetic Engines

Magnetohydrodynamic Propulsion.—NASA awarded contracts to General Electric Space Sciences Laboratories, Philadelphia, Pa.; Convair, San Diego, Calif.; Clauser Technology, Torrance, Calif.; and Marquardt Corp.-MHD, Inc., Van Nuys, Calif., to study magnetohydrodynamic (MHD) techniques for space propulsion.

Magnetohydrodynamics deals with electrically conducting high temperature gas (plasma) in the presence of magnetic and/or electric fields. The plasma is created by heating gas to such a high temperature that it breaks into positive ions and negative electrons. The gas then becomes a conductor of electricity and can be influenced and controlled by magnetic or electric fields.

The General Electric Laboratories investigated the development of a continuous-microwave magnetic accelerator. The principles on which such an accelerator would be built are (1) electron cyclotron heating, and (2) plasma acceleration by a magnetic nozzle.

Convair investigated a coaxial plasma gun as a possible electric engine. Such an engine would heat a gas by an electrical discharge between concentric cylindrical electrodes and then accelerate the gas in the annulus (space between the cylinders) by the pressure of a magnetic field for propulsion.

Clauser Technology studied the moving magnetic field technique for an MHD electric engine. In this method, a gaseous plasma, formed by ionizing the propellant gas, is pushed by a pressure from moving magnetic fields. The moving magnetic fields are produced by properly timed currents flowing in coils mounted outside the cylinder that contains the gas. The timing may be obtained by correctly energizing a series of individual coils, or by designing the coils as part of a transmission line.

The Marquardt Corp.-MHD, Inc., investigated plasma propulsion by means of a continuous-flow magnetohydrodynamic accelerator using multiple discharge points. This type of accelerator heats the gas by an electrical discharge and accelerates the gas in a channel by magnetic fields to develop power.

Steady-State Crossed-Field Plasma Accelerator.—This accelerator appears to have a number of important applications, such as a source of high-speed flow for aerodynamic testing and a propulsion system for spaceships. While not nearly so powerful as chemical rockets, its thrust is much greater than that of ion engines.

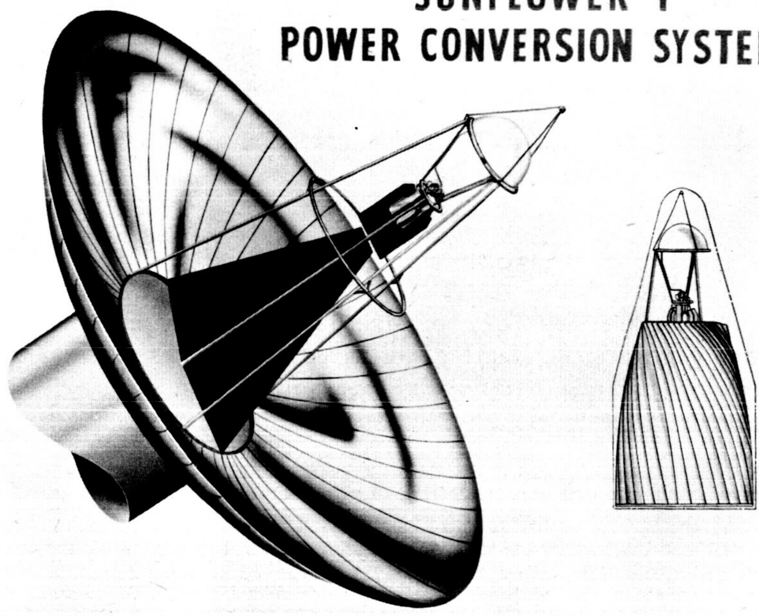
The Langley Magnetohydrodynamics Branch continued research on this accelerator and successfully accelerated plasma, increasing the total thrust up to 25 percent. Research will be continued and ultimately should produce an accelerator capable of producing a flow 20 or 30 times the speed of sound.

Sunflower Solar Electric Power Generating System

The TAPCO group of Thompson-Ramo-Wooldridge Corp., Cleveland, Ohio, is developing the Sunflower power system under NASA contract.

Sunflower is a project to develop a 3-kilowatt electrical power generating system for spacecraft. A 32-foot-diameter mirror focuses sunlight into a cavity receiver where it boils mercury circulated through tubes in the walls. The mercury vapor thus produced is expanded through a turbine which drives an electric generator. The

SUNFLOWER I POWER CONVERSION SYSTEM



mercury, leaving the turbine, is condensed in a radiator and pumped back to the solar-heated boiler to be recycled.

The mirror is made up of many petals so that it can be folded during launching.

This system has the potential advantages of low weight, lower cost than present solar-cell power systems, and long life in the space environment.

During the period, most of the preprototype versions of the major components and subassemblies were designed and fabricated, and special equipment and facilities for testing these devices were constructed. In the test program that followed, a number of problems—corrosion by boiling mercury, development of liquid mercury lubricated bearings, and containment of lithium hydride for use as a thermal energy storage material—were encountered. Work is continuing in an effort to overcome them.

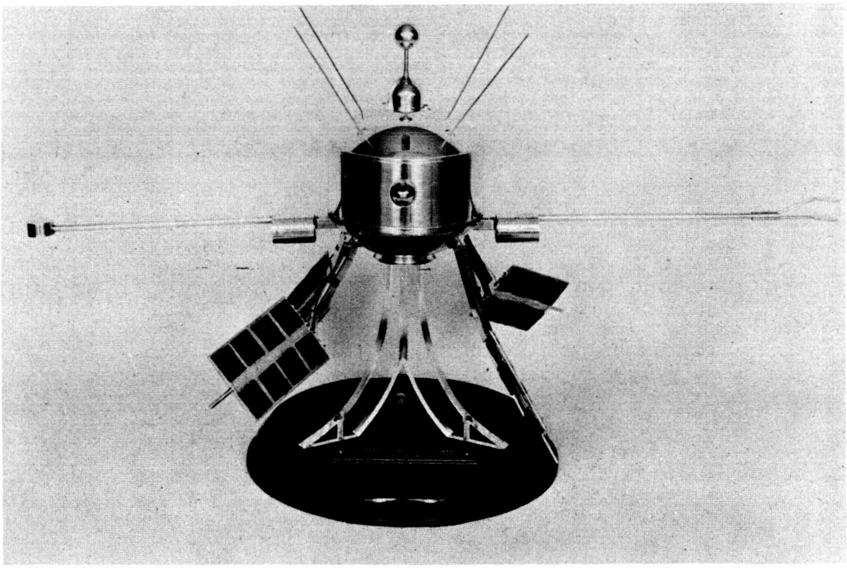
Satellite Development

Geophysical Satellites

Geophysics, the study of the earth and its environment, requires repeated observations to learn about variations in physical properties from day to night, day to day, and season to season. Among satellites planned for such scientific studies are the following:

International Ionosphere Satellite (U.K. No. 1) (S–51)

During the period, NASA and United Kingdom scientists continued their coordinated efforts on this international satellite venture. Instruments, including an electron density experiment and an ion mass spectrometer, are being prepared by the United Kingdom. NASA is building the satellite housing. Designed for an intensive study of the ionosphere, the satellite is scheduled for launch in 1962 by a Delta vehicle.



S–51 International Ionosphere Satellite

International Satellite No. 2 (S–52)

During the report period, NASA and British scientists selected experiments for the second United Kingdom-United States satellite. S–52 will be launched chiefly to gather data on galactic noise (natural radio waves from outside the solar system), the upper ionosphere, atmospheric ozone, and micrometeoroids. Payload planning continued as the period ended.

A Scout is scheduled to launch S–52 in 1963. Planned orbit is 1,000 miles at apogee, 230 miles at perigee.

Orbiting Geophysical Observatories (OGO) (S–49, S–50)

OGO is a standard satellite structure, complete with power supply, telemetry, data-storage facilities, and other basic equipment to serve 25 to 50 experiments—test devices—in compartments already connected to electrical power sources and telemetry equipment.

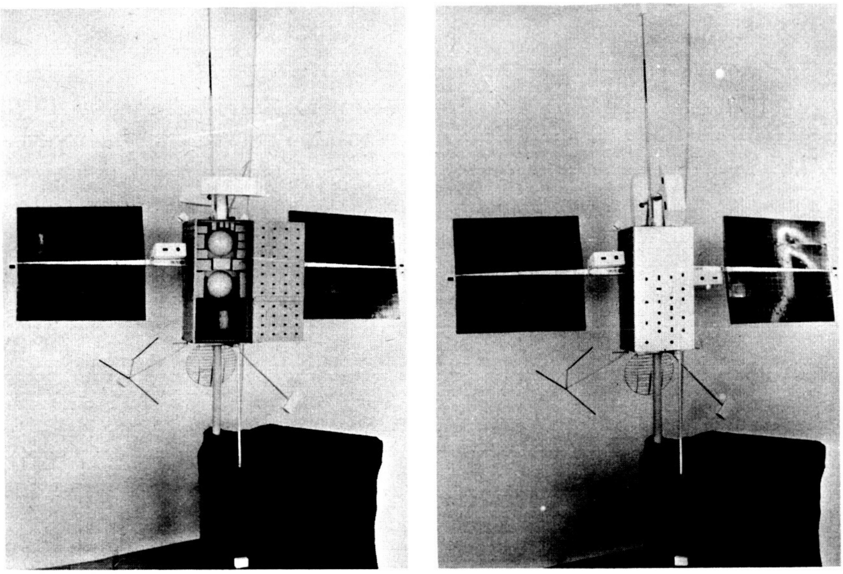
An Atlas-Agena B will launch one type of geophysical observatory satellite into an east-west orbit having an apogee of about 70,000 miles and a perigee of about 175 miles. Termed Eccentric Geophysical Observatory (EGO), the satellite will have as its main purpose the study of energetic particles and other geophysical phenomena requiring such an orbit.

Thor-Agena B will launch a Polar Orbiting Geophysical Observatory (POGO) into an orbit with planned apogee and perigee of 570 and 160 miles, respectively. POGO will be instrumented chiefly to study the atmosphere and ionosphere, with particular attention to the unexplored regions of the atmosphere above the poles.

Both EGO and POGO are OGO spacecraft, differentiated only by their orbits and experiments. Additional details on OGO appeared in NASA's Fourth Semiannual Report.

In January 1961, NASA issued a letter contract to Space Technology Laboratories, Inc. (STL), Los Angeles, Calif., to proceed with preliminary analytical and design studies of OGO. STL had been one of eight companies submitting proposals for design, development, construction, and test of the first three OGO's. In April 1961, NASA and STL agreed OGO would be designed as a boxlike structure, with movable solar-cell vanes for electric power, and booms or extensions for experiments that might be influenced by spacecraft structure or equipment. It would weigh 900 pounds—750 pounds of structure, stabilization-and-control, power, data-storage, and communications equipment; 150 pounds of scientific instrumentation.

By the end of the period, detailed design and development were in progress.



Two views of the Orbiting Geophysical Observatory (OGO) scheduled for launching in 1963

Astronomical Satellites

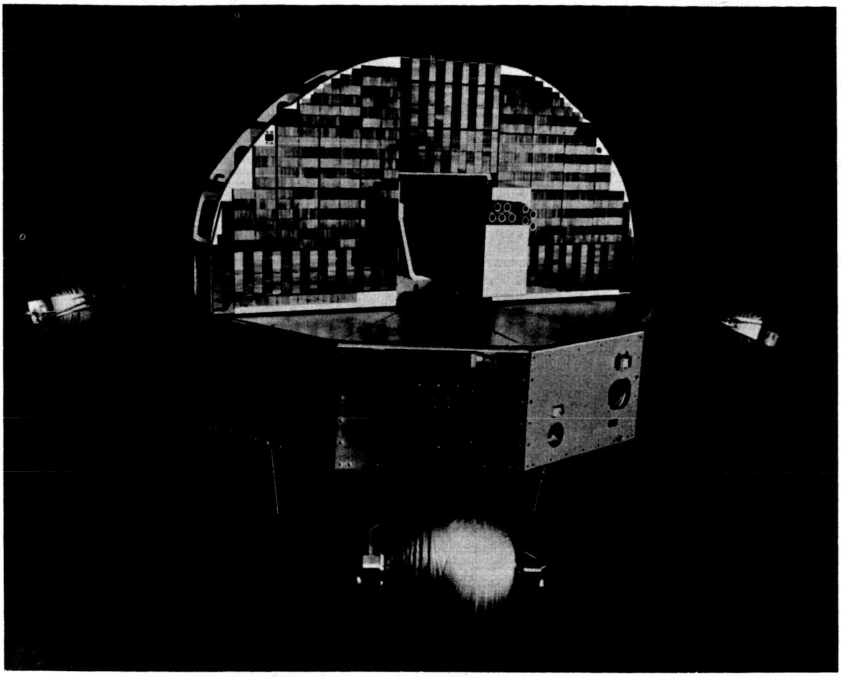
Orbiting Solar Observatory (OSO) (S–16, S–17)

All experiments in the solar-oriented and spinning-wheel sections of a prototype Orbiting Solar Observatory (OSO) functioned correctly in tests conducted at the Ball Bros. Research Laboratory, Boulder, Colo. Assembly of the 440-pound flight model was completed; experiments will be installed following evaluation of the prototype spacecraft. NASA has scheduled the first OSO (S–16) for launch by a Delta vehicle in 1962. A circular 300-mile orbit is planned.

OSO will be employed in an intensive study of the sun and its phenomena. This study will include detailed examination and monitoring of electromagnetic radiation from the sun, particularly radiation which cannot be studied by observatories on earth because it is blocked or distorted by the atmosphere.

S–16 instruments include (1) an X-ray spectrograph, (2) a Lyman-Alpha spectrometer, (3) low-energy and high-energy gamma-ray detectors, (4) neutron detectors, (5) specialized ultraviolet and X-ray detectors, and (6) equipment to determine the effect of the space environment on materials used in spacecraft.

Experimenters are scientists of Goddard Space Flight Center, Ames Research Center, the University of California, University of



The Orbiting Solar Observatory (OSO), a satellite to study the sun

Colorado, University of Michigan, University of Minnesota, and University of Rochester.

In May 1961, NASA released detailed plans for the second OSO (S–17) to scientists who will provide experiments for the spacecraft. The participating scientists are from Harvard University, University of Minnesota, University of New Mexico, Brookhaven National Laboratory, Naval Research Laboratory, and Goddard Space Flight Center.

Orbiting Astronomical Observatory (OAO) (S–18)

S–18 will be the first of a series[1] of satellites designed to observe the solar system and universe from above the distorting effects of the earth's atmosphere. OAO is basically a standardized "space platform," complete with stabilization, communication, and power equipment. It will be able to accommodate various types of astronomical observing devices, including, among others, telescopes with mirrors up to 36 inches in diameter; specialized spectrometers; photometers; and image-detecting tubes. Total weight will be approximately 3,500

[1] Plans call for an Atlas-Agena B to launch S–18 into a 475-mile circular orbit late in 1963. Subsequently, NASA plans yearly launchings of OAO.

pounds. The satellite platform will be about 10 feet long and 10 feet in diameter.

This highly advanced scientific satellite will carry about 1,000 pounds of scientific apparatus. It will be able to point instruments at a given star within a fraction of a second of arc (equivalent to focusing within one-third inch of a point a mile away).

During the period, Grumman Aircraft Engineering Co., OAO prime contractor, negotiated four main subsystem development contracts as follows: General Electric Co., spacecraft stabilization and control subsystem; Radio Corp. of America, TV scanner subsystem; International Business Machines, data-processing subsystem; and, Westinghouse Electric Corp., ground operating equipment.

In April 1961, NASA Headquarters and Goddard Space Flight Center, which is managing the project, contracted with Booz-Allen Co. for a study of an independent NASA reliability control program for the OAO project.

Meteorological Satellites

Nasa is developing meteorological satellites for worldwide observation of the atmosphere for both operational and research purposes. Data provided by such satellites will enable meteorologists to increase their understanding of atmospheric forces and to improve weather forecasts.

TIROS A-3[2]

Launch of TIROS A-3 has been scheduled to provide maximum coverage of the 1961 hurricane season in the North Atlantic and the Gulf of Mexico, and the major typhoon season in the Pacific. TIROS A-3 should thus record and transmit useful data on the origin and movement of these storms.

Significant improvements of TIROS A-3 over its predecessors are: Both TV cameras will be wide-angle to increase reliability and acquisition of the most valuable types of data; addition of a third radiation experiment, designed at the University of Wisconsin, to provide data on reflected solar and emitted infrared (heat) radiation from areas of the earth's surface about 1,000 miles in diameter. (In comparison, the wide-angle infrared radiometer in TIROS II[3] covered only about 450 miles at any one time.) Radiation data is used in research to

[2] TIROS A-3, launched July 12, 1961, became TIROS III. The satellite acquired excellent data on seven hurricanes, nine typhoons, and a number of less severe tropical storms. It first reported the cloud formation associated with the tropical storm later named Hurricane Esther.

[3] For details of TIROS II, see ch. 3.

increase meteorological knowledge; eventually, this research may lead to improved weather forecasting.

A third-stage blast deflector is being installed to minimize contamination of the camera lens such as occurred in the TIROS II experiment.

In March 1961, NASA completed negotiation of the TIROS A-3 payload contract with RCA Astro-Electronics Products Division, Princeton, N.J. Earlier, NASA had authorized the payload contractor to order long-leadtime items and to undertake some engineering.

More use will be made of TIROS A-3 than of its predecessors for practical analysis and weather forecasting. To this end, improved communications are being installed between the read-out stations (see below) and the National Meteorological Center, Suitland, Md. The center will incorporate TIROS data directly into its analyses and forecasts. In addition, cloud analyses similar to those issued for TIROS I and II will be disseminated to U.S. weather stations and foreign weather services.

NASA and the U.S. Weather Bureau invited foreign meteorological services to participate in the TIROS A-3 experiment by making ground-based weather observations simultaneously with satellite orbital passes. This program is analogous to that planned in connection with TIROS II.

Read-Out Station Moved

NASA completed the move of the east-coast TIROS read-out station from Fort Monmouth, N.J., to Wallops Station, Va. It had previously issued requests for bids to manufacture facilities similar to those at Fort Monmouth. The other TIROS read-out station is at Point Arguello, Calif. (See Chapter 14, "Construction of Facilities.")

TIROS Program Expanded

The demonstrated value of the TIROS cloud-picture data for weather forecasting makes it desirable to continue the TIROS program at least until the first successful Nimbus advanced meteorological satellite. Consequently, NASA extended the TIROS program to four launches beyond A-3, at approximately 4-month intervals. RCA Astro-Electronics Products Division, Princeton, N.J., will fabricate and qualify the necessary spacecraft, and RCA Service Corp. will operate the two read-out stations.

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Because it is stabilized by spinning, a TIROS satellite can observe the earth only a part of the time. (During major portions of each orbit, its cameras point away from earth.) Also, because the TIROS orbit crosses the Equator at an inclination of about 48° it cannot obtain significant data poleward of 55° latitude.[4]

Nimbus, an advanced meteorological satellite to follow TIROS, will overcome these limitations. Its television cameras and radiation sensors will always face the earth, and the satellite will be launched into a polar (rather than an inclined) orbit, so that it can photograph the entire globe at least once each 24 hours.

On February 3, 1961, NASA selected the Missile and Space Vehicle Department of the General Electric Co., Philadelphia, Pa., for contract negotiations to fabricate the basic Nimbus spacecraft structure, to integrate subsystems into it, and to test one prototype and two flight units, one of which will be flown as the first Nimbus (A–4).

A Thor-Agena B is scheduled to launch this 660-pound satellite in late 1962 from Point Arguello, Calif., into a 500-mile, circular orbit. It will carry at least three television cameras—improved versions of those in TIROS—oriented for almost horizon-to-horizon coverage. Nimbus will also carry infrared radiation equipment, including a device to furnish data on cloud cover at night, which the TV cameras cannot do.

Instruments will be powered by solar cells, augmented by storage batteries. Included in the payload will be tape recorders and telemetering and command equipment.

Later spacecraft may also carry additional or improved sensors, such as (1) redundant TV cameras, (2) more and improved infrared detection equipment, (3) Image Orthicon cameras for nighttime cloud data, (4) an electrostatic tape camera to obtain more details on cloud patterns and types, (5) a spectrometer to measure atmospheric temperatures and the distribution of water vapor, and (6) radar to observe lower cloud layers and precipitation. Orbit altitude may be increased to about 600–750 miles.

Nimbus will be controlled from a data read-out station under construction at Fairbanks, Alaska. Communications are being established for transmitting the data rapidly from Fairbanks to the National Meteorological Center to be used in weather analysis and forecasting. Afterwards, the information will be made available for research and climatological studies.

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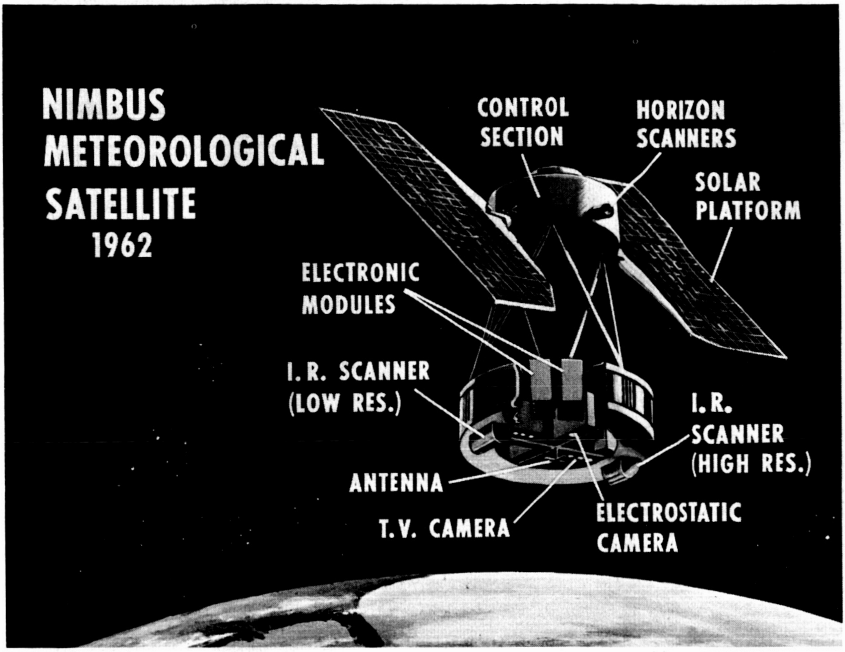
[4] NASA will attempt to launch some later TIROS satellites in 60° orbits to increase coverage to about 65° of latitude.



Nimbus will serve as the basis for the first operational meteorological satellite system.[5]

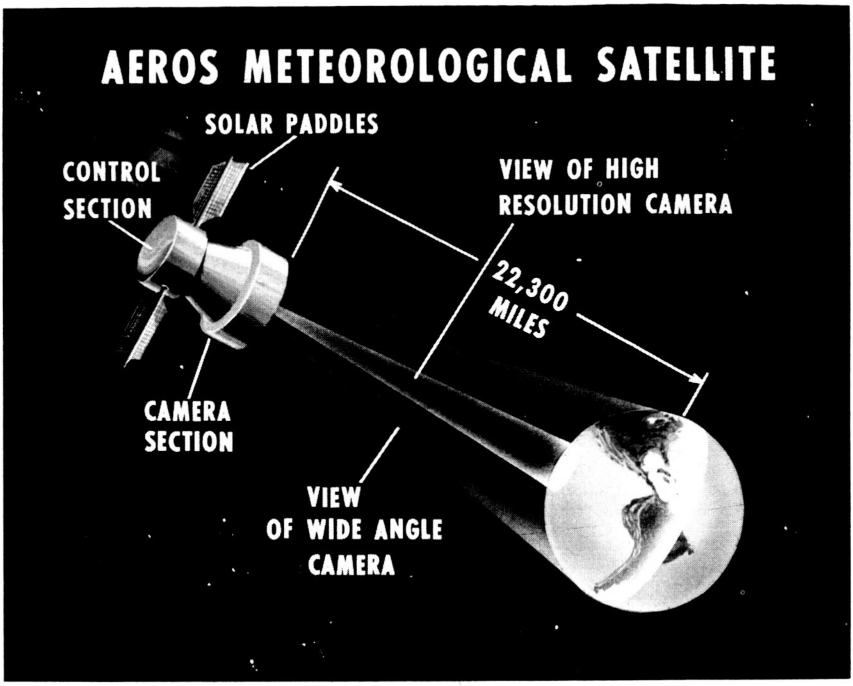
Aeros

The Aeros family of meteorological satellites—at present still in the concept stage—would be designed to enable meteorologists to observe storms continuously from their earliest stages to their ends. NASA plans to launch Aeros satellites into "stationary" orbits; that is, into orbits that are 22,300 miles above and parallel to the equator. A satellite in such an orbit takes as long to travel around the earth as the earth to rotate on its axis (about 24 hours). Thus, the satellite remains more or less over a specific geographic area on the equator.

Since Aeros would be fixed over the Equator, it would not be able to view the polar regions. Such observations would be made frequently by the polar-orbiting Nimbus. Aeros can view temperate and tropical latitudes.

Principal instrumentation of Aeros would be a system of TV cameras, probably with variable focus lenses of the "Zoomar" type, which can take pictures of a storm area under observation in varying degrees of detail. Instruments of Aeros, like those of Nimbus, would always

[5] NASA and the U.S. Weather Bureau are jointly implementing the National Operational Meteorological Satellite System. Funds for initial implementation of the system were authorized in an appropriation signed by the President in October 1961. (See Chapter 3, "Satellite Applications.")



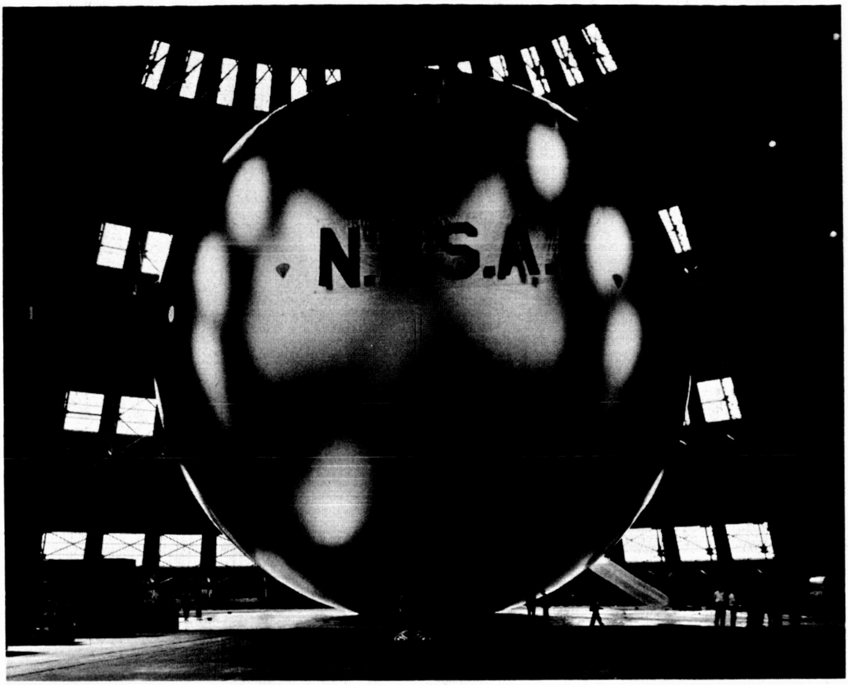
point toward earth. NASA has requested funds for fiscal year 1962 to study, start design of, and develop the optimum camera system for Aeros.

Communications Satellites

Echo

Success of the Echo I experiment (see NASA's Fourth Semiannual Report to Congress) has led to the continuation of the passive communications satellite program. In February 1961, NASA negotiated a $400,000 contract with the G. T. Schjeldahl Co., Northfield, Minn., to design, develop, fabricate, and test rigidized inflatable spheres for future launchings in the Project Echo series. These spheres will be 20 times more resistant to buckling and deformation than Echo I and should have a long useful life in space. Fabricating and testing began during the report period.

Echo II is scheduled for suborbital flight tests early in 1962, and for launch later that year by a Thor-Agena B into a 700-mile, circular polar orbit. The Echo II sphere will be about 135 feet in diameter, weighing approximately 600 pounds. Made up of a layer of laminated aluminum foil (0.20 mil thick) on each side of a film of Mylar plastic (0.35 mil thick), the skin will have a total thickness about that



The Echo II passive communications satellite is test inflated. The 135-foot-diameter sphere folds into the 44-inch canister (foreground) for launching

of the foil on a cigarette package. To maintain heat balance, the surface of the sphere will be chemically coated.

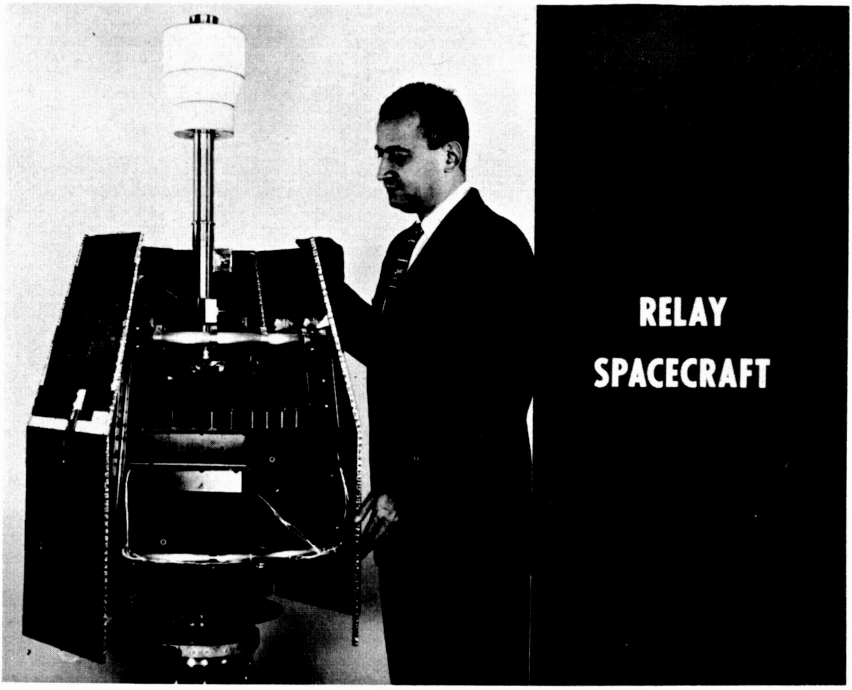
Relay

Relay will be an active communications satellite weighing about 100 pounds, traveling in an elliptical orbit between 900 and 3,000 miles above the earth. Delta will be its launch vehicle, with the first orbital shot scheduled for 1962. NASA has awarded a $3 million contract to Radio Corp. of America to design, test, and manufacture Relay.

The eight-sided, barrel-shaped unit will contain two communication sets to receive and retransmit television, two-way telephone, and other signals. Relay will also carry equipment to measure the effects of radiation on solar cells and the effectiveness of various amounts of shielding. Power will be furnished by 6,000 solar cells mounted on the satellite's sides.

Rebound

Rebound is a spacecraft for orbiting several satellites with a single launch vehicle. The advantages of such a device, aside from economy,



are the possibility of spacing satellites uniformly and reducing the number of satellites needed to provide continuous communication.

The first Project Rebound launch is planned for 1963. NASA will employ an Atlas-Agena B to orbit three satellites at an altitude of about 1,700 miles. Two such experiments are planned.

In July 1961, NASA awarded a $450,000 contract to Douglas Aircraft Co., Inc., Santa Monica, Calif., to conduct a design study and develop preliminary specifications for the Project Rebound spacecraft.

CHAPTER 10

Research Primarily Supporting Aeronautics Activities

Aeronautics Research Covers Wide Range

In aeronautics research,[1] NASA is placing special emphasis on (1) the supersonic transport, capable of extended flights at speeds as high as 2,000 m.p.h.; (2) the X–15 rocket-powered research airplane, designed for speeds from 2,000 to 4,000 m.p.h. and an altitude in excess of 50 miles; (3) Dyna-Soar, the rocket-boosted hypersonic glider for exploring the speed range between 4,000 and 18,000 m.p.h. (orbital velocity for earth satellites); (4) helicopters and other vertical takeoff and landing (VTOL) and short takeoff and landing (STOL) aircraft, and (5) a wide range of other technical problems in aeronautical research and flight safety.

In these areas, NASA is carrying on the work of the National Advisory Committee for Aeronautics (NACA) which for 43 years maintained close relations with the aircraft industry and the military, providing research information, coordination, and advice. NASA, which absorbed NACA on October 1, 1958, is continuing this service.

The greater part of NASA's advanced laboratory research in aeronautics is carried out at the Langley, Ames, Lewis, and Flight Research Centers, and at Wallops Station. Some advanced research is also conducted under NASA contract or grant by the Nation's universities, research institutions, and by private industry.

Research on the Supersonic Transport (SST)

Three Agencies Study SST Development

Development of the supersonic commercial transport is being jointly studied by the Department of Defense, NASA, and the Federal Aviation Agency (FAA). (The roles of the three agencies are de-

[1] Although the distinction between aeronautics and space research is not always clearly defined, the two areas are discussed separately in the report for convenience. Space research activities are set forth in ch. 11. The X–15 research airplane, a NASA-Air Force-Navy project, and Dyna-Soar, an Air Force-NASA supported project, are described in ch. 12.

lineated in ch. 20.) A report on their coordinated studies of the problem was issued in June 1961.[2] The task group making the study concluded that "* * * a well-organized national effort is required to produce an economically competitive commercial supersonic transport by 1970 * * *" for continued U.S. leadership in world commercial aviation, for national prestige, and for economic reasons.

New York to London in 2 Hours.—According to the report, the SST is to be designed to cruise at Mach 3 (more than 2,000 m.p.h.) over a range of some 3,500 miles, at altitudes above 70,000 feet. This speed would enable the SST to carry 120 or more passengers from New York to London in less than 2 hours. A substantial investment will be required to develop and produce such an aircraft, but the SST will have the ability to carry more passengers and to make more trips (up to five a day) than today's aircraft.

Aerodynamics

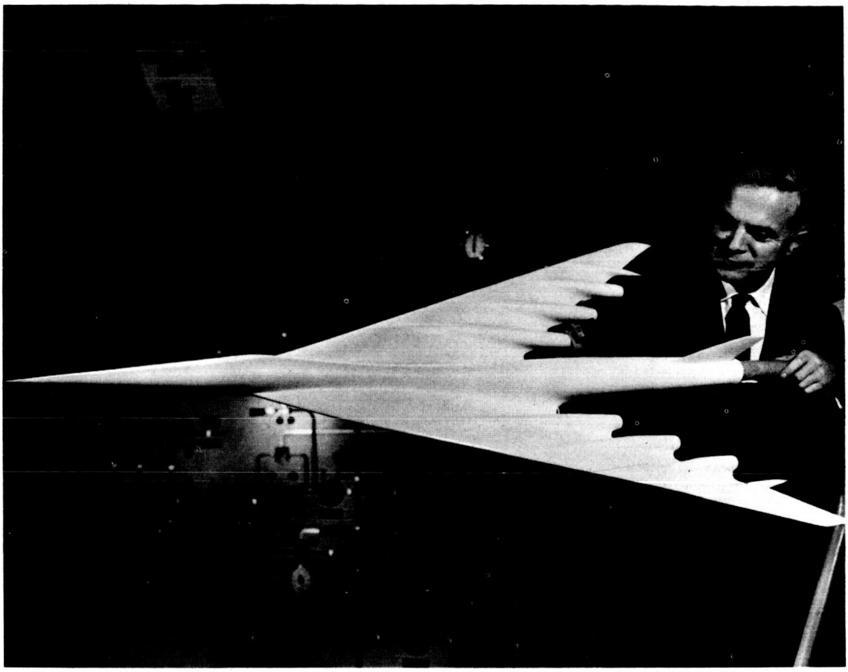
NASA's investigation of designs for the supersonic transport progressed through wind-tunnel tests at Langley Research Center of a variable-sweep wing; that is, a wing that can be extended or swung back mechanically. It is extended for lift at low speeds (takeoff, climb, approach, landing); it is swung back to reduce drag at high speeds. The wind-tunnel tests indicated that the variable-sweep wing can be designed for efficient operation and balance at all speeds.

Langley has concurrently investigated the possibility of applying the variable-sweep wing to military aircraft. Wind-tunnel tests of the stability and control of this type of airplane at low speeds have given good results.

In other studies of the problem of making the high-powered SST efficient at low as well as high speeds, NASA scientists have looked into the possibility of using excess engine power to supplement lift during landing. In studies conducted in the Ames Research Center's 40- by 80-foot wind tunnel, progress was made in improving performance by deflecting the engine jets or using auxiliary lifting fans driven by the engines.

Aerodynamic Heating.—At speeds of 2,000 m.p.h. and higher, external surfaces of the SST will be exposed to operating temperatures ranging from 450° to 600° F. Metals used in the structure must be able not only to withstand these high temperatures, but also to keep their structural strength during extremely frequent changes in temperature. For this requirement, titanium and stainless steel, which retain their strength at temperatures well above 500° F., appear

[2] Commercial Supersonic Transport Aircraft Report, June 1, 1961, Department of Defense, National Aeronautics and Space Administration, Federal Aviation Agency, vi+48 pp.



One of the designs being studied for the supersonic transport. The pinched fuselage and the engine nacelles on the upper surface of the wing-trailing-edge are designed to minimize drag at supersonic speeds

promising, but many tests and studies in the laboratory and in flight will be necessary to find out whether they will meet the needs. Metals in the fuselage must also withstand constant "flexing," which can produce fatigue, or weakness, and finally rupture.

Materials other than metal—for example, sealants, lubricants, hydraulic fluids, glazing materials, and other items—must show similar resistance to high temperatures and other extremes of operating conditions.

Heat will also be a problem with the vehicle's internal systems and even with the passenger compartment itself. The aircraft must therefore be designed to have some type of cooling or insulation system to keep the interior at suitable temperature levels.

A number of methods for solving this problem have been advanced, but most considered to date have apparent serious drawbacks. To insulate the cabin against the heat generated at the SST's cruising speed would require materials a foot thick, resulting in an unacceptable amount of weight. Conventional air cooling is also apparently not the answer, because the weight of the required equipment is prohibitive.

Sonic Boom

One of the most severe operating problems of the commercial SST is noise because of its effects on both the aircraft structure and on the public. NASA is progressing with research on jet noise to learn more about its causes and ways of suppressing it. The sonic boom (a noise like artillery fire caused by an aircraft travelling at or above the speed of sound) can crack windows, damage structures on the ground, and disturb entire communities. The SST, because of its great size, may produce a more intense boom than that of any airplane now operating.

NASA laboratory and flight research, with supersonic aircraft, advanced knowledge of sonic boom and how to minimize it. It was found, for example, that the noise of the sonic boom increases two to four times when an aircraft accelerates or turns. These data will be used in further investigations of supersonic aircraft to help predict the boom and to devise operating techniques to minimize its effect on the ground.

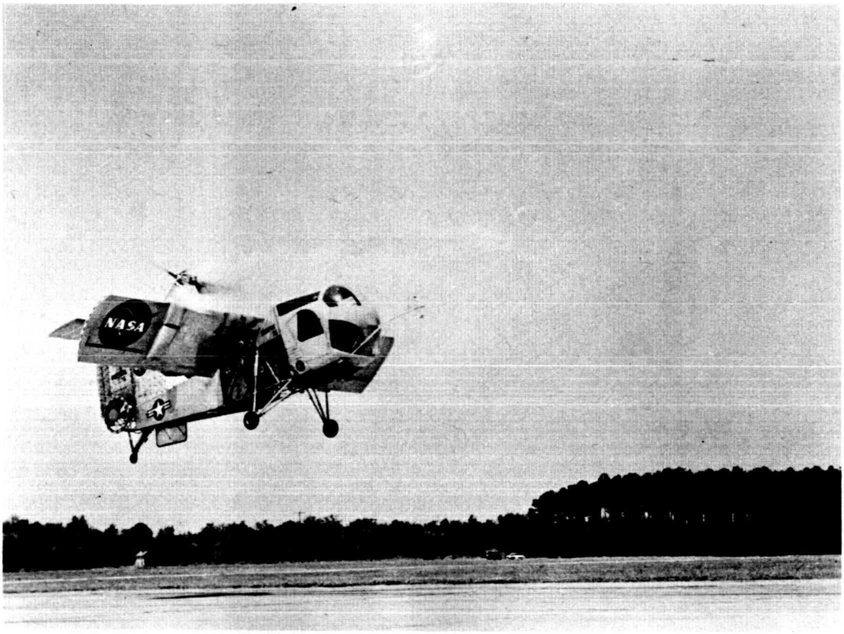
Operating Problems

Takeoff noise will likewise be greater than that of today's jet transports, and may therefore strongly influence the location of airports of the future. Higher landing and takeoff speeds and increased weights of SST aircraft raise questions about the ability of present airport runways to handle the SST. Current research on increasing lift at slow speeds may enable the SST to employ the facilities now used by subsonic jet transports. However, SST landing gear must be designed to spread the weight to prevent breaking up runways.

Langley research on problems associated with the takeoff of the SST showed that the pilot of a supersonic transport will need a single, compound instrument for reference in order to maintain a steady path during climb from takeoff. The device should show changes in speed and altitude simultaneously. Studies on such an instrument are underway.

Use of Simulators and Computers for SST Studies.—In studies of the flight capabilities of the SST, Ames Research Center used analog computers to supply information to the displays and controls of flight simulators. By these techniques, the handling qualities during landing approach and touchdown of an aircraft of SST configuration were investigated.

The Center also studied the effects of small disturbances encountered during cruise flight on the airplane's flight path and attitude. It was found that the supersonic transport, like other supersonic aircraft, would not have sufficient inherent stability for acceptable flying qualities during normal operations; thus mechanical reinforcement of stability would be desirable.



The Boeing Vertol 76 is one type of VTOL aircraft. Its wings and propellers tilt from the vertical for takeoff to the horizontal for level flight

Research on VTOL/STOL Aircraft

NASA scientists have concluded that a combination VTOL/STOL aircraft is in many respects preferable to two separate types, because in operational use both the VTOL and STOL capabilities will be required under various conditions of payload and terrain. NASA research on problems related to these craft continued at the Ames and Langley Research Centers.

V/STOL aircraft appear to have useful applications for both military and commercial users. In military use, such vehicles could be employed for cargo and troop transportation, for reconnaissance, for surveillance, and for other frontline and close-support missions. The V/STOL may very well be the answer to the need of the ground forces for speed and mobility far greater than they now possess.

Commercially, the VTOL and STOL transports hold considerable promise for short-haul cargo movements and for airport-to-city commuting. Although more costly to build than the conventional transport, the V/STOL should more than offset the difference by the time saved in moving goods and passengers from city center to city center.

Bell X–14 Modified for Flight Tests

Modification of the Bell X–14 for use as a variable-stability VTOL airplane for flight tests was started at Ames Research Center. The craft has been flown in both hovering and normal forward flight, and has successfully made the transition from one to the other. Data obtained and the pilot's evaluation of aircraft performance are being used in conjunction with wind-tunnel studies to select the best design.

The tilt duct is another type VTOL aircraft under flight study by NASA

First Tests Completed on VZ–2

The VZ–2 is a two-propeller, tilt-wing VTOL aircraft with a shaft-turbine engine, built for the Army and the Office of Naval Research. Tested at Langley, the aircraft was found to be limited to very slow rates of descent; at faster rates, the design of the airfoil, or wing, appeared to give the VZ–2 a tendency to stall. To overcome this deficiency a dropped "leading edge" was added to the airfoil. This device worked very well, increasing the usable rate of descent more than enough for ordinary operations. The same arrangement should be applicable to other aircraft of this general type.

Wind-tunnel tests of a full-span, large-chord flap added to the wing also gave good results. This arrangement not only relieved stalling problems, but gave good means of directional control.

Improving Helicopter Design

The Langley Research Center investigated effects of the fuselage shape and external components (hubs, pylon, antennas, rotors, landing gear) on the performance of helicopters. The study resulted from U.S. Army needs for a helicopter with longer range and greater cruise efficiency than those now in service. Research showed that the drag of the fuselage and other parts consumed much of the total power of the helicopter.

Data collected in wind-tunnel tests indicated that smoothing and streamlining only the fuselage and the skid-type landing gear reduces drag substantially. These findings are being applied to helicopters in use at present and will help in design of future models.

Other Aeronautics Research

Variable Stability Airplane Prepared for Flight

The design, development, and installation of a three-axis, variable-stability system in an F–100 airplane has been completed, the equipment has been checked out, and the airplane has been turned over to the NASA Flight Research Center. This gives NASA, for the first time, three-axis variable stability in a modern high-performance airplane.

Paraglider Research

The paraglider is an extremely lightweight glider that can be packaged much like a parachute. Such a device is under serious consideration for recovering rocket boosters for reuse, making studies of the space environment, delivering military weapons, and, possibly, recovering space capsules.

The Department of Defense is providing funds to construct test vehicles of this type to investigate the use of the paraglider as a means of arms mobility. NASA research support has included wind-tunnel studies of the paraglider from low speed to Mach 4.65; stable, radio-controlled glides of paragliders of 7- and 16-foot wingspans; and stable, radio-controlled flights of model airplanes using the parawing as the lifting surface.

Flight Safety

Water Pond Arresting Gear

In 1961, NASA expended much research effort on problems of flight safety in civil aircraft operation. At the request of the Federal Aviation Agency (FAA), an investigation was made of a method of stopping aircraft from overrunning the end of the runway by use of a shallow pond of water. The FAA request was based on the need to develop a method of stopping turbojet planes when they are forced to abort takeoff or when they overrun on landing as the result of brake failure or other causes. The arresting gear desired would be such that it would not require any substantial changes in, or appendages to, the aircraft.

Tests were conducted by launching a scale model of a typical jet transport into a pond whose depth could be changed readily. Landing gear and flaps of scale strength on the model made it possible to assess structural damage.

It was found that a water pond 3 feet deep will stop a jet airplane within 1,000 feet at entry speeds of up to 115 m.p.h. At speeds below 58 m.p.h., the airplane would probably be virtually undamaged. At higher speeds, with present-day landing gear and flaps, some damage would occur.

Tire Designs for Safety

Another problem investigated at Langley during the year was the poor braking ability of jet aircraft on wet runways. Tires reinforced with fabric for longer life, used on jets, are unsatisfactory. They have simple tread designs because of manufacturing difficulties with the fabric material. These tread designs are satisfactory for propeller-driven aircraft, which can use reverse thrust to help braking, but jets have much less reverse thrust than prop-driven aircraft and are thus more dependent on tires for braking.

Research at Langley showed that fabric-reinforced tires, with simplified tread design, had, in some cases, only one-third the braking efficiency at high speed of the tires of older design. Langley developed a design for a fabric-reinforced tread which is about equal in braking efficiency to the older type. NASA made the results available to aircraft tire manufacturers.

Investigation of Effects of Slush on Runways

NASA scientists investigated the effects of slush on runways with a specially-designed, 100,000-pound test car at Langley's landing loads track facility. Technologists found that one-half inch of slush requires 1,000 feet of extra runway for the takeoff of a jet transport. Another finding was that in a high-speed run, slush is thrown into all openings on the aircraft, including jet engine inlets. It can damage the vehicle and seriously interfere with safety of operation. This information will be used by the Federal Aviation Agency in further studies to establish regulations for jet transport operation on runways that are slushed over.

Ames Flight Simulator Put in Operation

The new Ames flight simulator capable of simulation in three dimensions was placed in operation with the pilot "flying" this new operational research tool for the first time on November 4, 1960. In the first research project, an analog computer was employed to simulate the control power and damping requirements for hovering VTOL/STOL aircraft. The new equipment made it possible to determine the effect on the vehicle in flight when the pilot must cope with three angular motions simultaneously.

In discussions of the test results at the conference on VTOL/STOL problems held at Langley on November 17 and 18, 1960, pilots reacted favorably to the smoothness and precision of the gimbal-drive system of the new simulator. They disapproved the mechanical characteristics of the cockpit controls, which can be changed to match the requirements of a variety of individual research programs.

Studies of Pilot Performance at Zero G

As part of the Ames Research Center's broad research on the ability of pilots to perform useful tasks under various forces of acceleration, special equipment was developed and installed in an F–104B two-seat supersonic airplane. The research will be conducted at the NASA Flight Research Center, Edwards, Calif. In test flights, the pilot in the front cockpit will fly the airplane on a straight parabolic course so as to provide weightlessness or zero g for about 1 minute. During this period the pilot in the rear cockpit will perform various assigned tasks. The ability of the pilot to perform his tasks will be evaluated, and various measurements of physiological condition (pulse rate, blood pressure, etc.) will be recorded. For purposes of comparison, similar evaluations and measurements will be made at other levels of acceleration up to 3 g. This research information will be compared with results obtained in the X–15, Project Mercury, and other programs.

Space Activities Research

NASA Studies Space Flight Paths

With emphasis on earth-moon voyages, NASA's research centers—in cooperation with private industry and educational and research institutions—have stepped up their studies of the myriad problems involved in manned space travel. Representative investigations include navigation, guidance, and control; spacecraft rendezvous techniques; launching from the surface of the moon to return to earth; and determining the "corridors" for entering the earth's atmosphere.

Underlying these theoretical studies—most of which are conducted with the aid of flight simulators and giant computers—is the science of "celestial mechanics," which deals with the motions of two or more bodies in space and the complex interrelationships of their gravitational attractions.

Rendezvous and Trajectory Studies

A spacecraft's trajectory or flight path determines how much fuel will be required for the journey, the total weight that can be carried, the acceleration or "g" forces the crew must undergo, and the amount of radiation that will be encountered in space. Plotting a course for a space voyage requires a far greater degree of precision than that required for conventional navigation of ocean vessels or airplanes. There is practically no room for error, even a slight miscalculation can be fatal.

Consider, for example, a manned Apollo spacecraft returning to the earth from the moon at 25,000 m.p.h. The vehicle must enter, with utmost precision, an extremely narrow "corridor" through the outer reaches of the earth's atmosphere. If it comes in too high, the craft may "skip off" and travel over a distant orbit before returning to earth, if it returns at all. If too low, the spacecraft will strike the dense lower part of the atmosphere much too soon, and runs the risk of destruction by the intense heat that is generated.

The width of the "corridor" will vary according to such factors as the amount of "lifting" surface on the spacecraft, the degree of guidance and control it possesses, and the amount of fuel it can carry to apply retrograde, or breaking, thrust.

Studies of Mission Staging by Rendezvous.—Mission staging by rendezvous [1] has been the subject of concentrated investigation at the Marshall Space Flight Center, the Jet Propulsion Laboratory, and the Langley, Ames, and Lewis Research Centers. The work has involved analytical and simulator studies of orbital mechanics, and control and guidance problems as applied to rendezvous.

The theory of orbital rendezvous is based upon principles of celestial mechanics—for example, if two objects are launched into identical orbits, they will circle the earth at the same speed, and with the same perigee,[2] apogee,[3] and inclination [4] to the Equator. Theirs speeds relative to each other will be zero; hence, they can be maneuvered into position and joined in orbit, in much the same way that one airplane can refuel another in flight.

With rendezvous techniques it should be possible to carry out a flight to the moon in a series of steps, using several relatively small launch vehicles rather than the much larger one required for a "direct ascent" method. However, many problems remain to be resolved, both in theory and practice. Some critical questions already under study include launch timing, automatic and piloted guidance of the vehicles to a rendezvous, orbital refueling, and attachment of self-contained spacecraft units.

Rendezvous concepts that will be considered for the lunar mission include, for example, rendezvous in earth orbit; in lunar orbit (for the return flight); after lift-off from the lunar surface; in both earth and lunar orbit; and on the lunar surface.

Ames Studies Rendezvous Problems.—Ames Research Center is carrying out theoretical studies of three possible methods of space rendezvous: (1) "Salvo" launch, in which the spacecraft that are to be brought together in space are fired simultaneously; (2) "sequential intercept," the firing of spacecraft toward rendezvous at different times; and (3) "interorbital transfer," or the maneuvering of one spacecraft into the orbital plane of another.

Scientists tentatively conclude that the salvo method appears to have payload advantages, in that it requires less fuel than other methods to bring the spacecraft together; this system also presents a relatively simple guidance and control problem.

Langley Completes Lunar Trajectories Study.—Langley Research Center completed a study defining the characteristics of trajectories for a manned spacecraft to circle the moon and return to earth. The

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[1] Bringing space vehicles to within 100 to 1,000 feet of each other while in orbit.

[2] Perigee—in an elliptical orbit, the point at which a satellite is closest to earth.

[3] Apogee—in an elliptical orbit, the point at which a satellite is farthest from earth.

[4] Inclination—the angle between the plane of an earth satellite's orbit and the plane of the earth's Equator.

study defined such details as time of flight, distance of approach to the moon, and "injection" energy [5] for the families of trajectories that will permit return to earth through an acceptable "entry corridor."

Two possible classes of circumlunar trajectories can be used for the manned missions: direct-entry trajectories, which come back into the atmosphere in the direction of the earth's rotation; and retrograde-entry trajectories, which come in from the opposite direction. Guidance studies to define the accuracies required at injection into the circumlunar trajectory, and the effects of making midcourse velocity corrections at various points throughout the trajectory, show that the retrograde entry path will be less sensitive to injection errors than the direct entry path.

Langley Analyzes Lunar Navigation Studies.—Langley Research Center has been studying a manually controlled spacecraft navigation system for making lunar landings.

The navigation system is light in weight and simple to operate; it consists of a timing device, a gunsightlike optical instrument, and a doppler radar unit. The optical instrument, with a built-in grid system, permits the operator to make visual estimations of distances and directions. The general operation of the device is somewhat analogous to that of a slide rule, although there is, of course, no physical similarity.

Results with this system, which will weigh only 10 or 15 pounds, are comparable in many respects to those obtained with automatic systems weighing 100 to 200 pounds. The considerable savings in weight in the payload is extremely important, because of the need for many pounds of fuel in the booster for each pound of payload.

Using the above system, which has been built and tested in the laboratory, the lunar landing procedure would be somewhat as follows:

As the spacecraft approaches the moon, it is injected into the lunar orbit at the relatively low altitude of 100,000 feet (about 18 miles) above the lunar surface. From the orbiting spacecraft, a smaller unit, manned by one or two of the three-man crew, detaches and slows its speed by firing retrograde rockets. The unit then drops to the lunar surface, touching down in a vertical position.

In the return maneuver, the unit blasts off vertically from the surface of the moon until it reaches the 18,000-mile orbital altitude, at which point it applies the necessary power and guidance to achieve orbital velocity and rendezvous with the still-orbiting spacecraft.

The system described has a number of advantages, foremost among which is a sizable reduction in the amount of propellant required for the lunar lift-off; this, in turn, reduces the overall amount of weight

[5] "Injection" energy—the power required to place a spacecraft in orbit.

that must be put into an "escape" trajectory for the voyage back to earth.

The lunar landing studies are continuing, with special emphasis on the role of the pilot.

Interplanetary Navigation Studies at Langley.—Langley continued studying interplanetary navigation techniques, employing an IBM 7090 digital computer. The program has the following objectives: To provide basic information on several types of navigation systems; to study instrumentation requirements; and to explore ways of improving the accuracy of the various so-called *constants* required in interplanetary navigation.

The primary effort thus far has been on the navigation systems, with interplanetary flight divided into three phases:

(1) escape from the earth-moon system;

(2) heliocentric [6] flight to the planet in question; and

(3) flight in the vicinity of the planet.

The first phase requires guidance navigation for launch and heliocentric injection. In a typical Earth-Mars flight, for example, the first phase would end 575,000 miles from earth. The second phase, which involves midcourse navigation, in our chosen example would end about 360,000 miles from Mars. Guidance navigation in the third phase of the flight depends upon the spacecraft's mission, and whether or not a landing is part of the plan.

The Langley midcourse navigation study investigated "fixed-arrival time" and "variable-arrival time." In the former, the first system studied was a celestial mechanics concept known as "two-body" navigation. This system is used to determine the velocity required to complete the mission at some fixed date. It provides a useful standard for evaluating and comparing other navigation guidance systems. Using this form of guidance on a typical trip to Mars with arrival scheduled in 220 days, it was found that 7 percent of the total spacecraft mass at the time of heliocentric injection would be the amount of propellant required to make orbital corrections—that is, to make required changes in course in order to land on Mars.

Further analysis of the two-body navigation equation indicated that it could also be employed to determine accurately the velocity of the spacecraft, using "position" data—an important capability representing a solution to one of the more important problems of space navigation.

In addition, the two-body navigation equation makes it possible to make all the mathematical determinations required to guide the spaceship on a return to earth at any time during the interplanetary trip,

[6] "Sun-centered." The spacecraft must be placed into a portion of a solar orbit en route to the destination planet.

and—since the equation can be solved without computers—it will furnish the basis for an emergency manual "backup" system.

In the second part of the study, the "variable-arrival time" navigation system, a logic was derived that applies to all phases of space flight, and selects its own orbit to target. This system is being programed into the 7090 for the lunar mission.

The work on guidance techniques has emphasized systems with versatility, accuracy, simplicity, and efficiency, and has led to a number of promising concepts. Programs to be developed will emphasize investigation of optimum instrumentation techniques, including studies already started to determine the effects of probable instrument errors and corrective-thrust errors on the accuracy and efficiency of proposed techniques.

Ames Attacks Entry Landing Problems.—An Ames study has indicated that the range of a spacecraft's flight after it has entered the earth's atmosphere can be varied widely, permitting considerably more latitude in choosing landing points than was formerly thought possible. By designing the spacecraft with at least a moderate "lift-drag" ratio, the range can be varied from a minimum of 1,000 miles to a maximum of about 15,000 miles—more than half the distance around the earth.

Materials Research

Ames Studies Ablative Heat Shields

The properties and performance of a number of ablative materials [7] for protecting spacecraft surfaces against the enormous heats generated during atmospheric entry have been determined in the Ames atmosphere entry simulator for various conditions at entry speeds up to 20,000 feet per second (14,000 m.p.h.) and satellite speeds up to 25,400 feet per second (18,000 m.p.h.).

Research is also being carried out on ablative materials in arc-heated airstreams at lower heating rates to which some parts of entry vehicles will be exposed during their descent. Preliminary results indicate that Teflon plastic remains fully effective down to the lowest heating rates of the tests, whereas the effectivenes of polyethylene plastic appears to diminish, because at the lower rates it ablates in liquid rather than gaseous form.

Investigation of Tungsten Characteristics.—Lewis Research Center is carrying on vigorous research with tungsten, which has one of the highest melting points of any metal (about 6,150° F.), but is difficult to work with because of its brittleness, or poor ductility. Research

[7] Ablative materials include plastics, ceramics, cermets, etc., which are converted to gases by aerodynamic heating; these gases dissipate much of the heat as they flow back over the vehicle.

has indicated that, at ordinary room temperatures, the bend ductility of a test specimen of tungsten depends a great deal on its surface conditions. For example, researchers found that when a thickness of about 10 mils was electropolished from the outside surfaces of a ⅛-inch diameter tungsten rod, the bend ductility increased as much as sevenfold.

To gain a better understanding of the reasons for the improved ductility after electropolishing an investigation was conducted in which the temperature was determined at which recrystallized tungsten specimens given various surface treatments made the transition from brittleness to ductility.

For example, the brittle-to-ductile transition temperature of electropolished specimens was approximately 415° F.; specimens which were surface ground, after electropolishing, to give an even smoother finish (30 r.m.s.), had a transition temperature of 5° F. The transition temperature of specimens containing a single sharp notch (radius 0.0015″) was approximately 750° F.

The results of the investigation emphasized that the slightest "notch" in the surface of the tungsten affects the ductility greatly, and that the major benefit derived from electropolishing is apparently the removal of surface scratches. Such scratches appear to have the effect of concentrating stress and starting cracks in the surface. An appreciation of the role of surface defects should be of considerable assistance to fabricators who must produce complex shapes from this difficult-to-form material.

Materials for Passive Communication Satellites

A preliminary NASA study (American Astronautical Society Preprint No. 60–4) has shown that present construction of passive communication satellite structures is relatively primitive. For example, only 4 pounds of aluminum are required on a 100-foot sphere to reflect radio waves, but it takes more than 100 pounds of structural material to support or deploy the 4 pounds of reflecting material.

Scientists are searching for a material that will minimize the reflection of all electromagnetic radiation except that in the frequency range of 1 to 10,000 megacycles per second (1 to 10 KMcps). Such a material would reflect radio signals, but be "transparent" to light waves in order to reduce the effects of solar pressure of sunlight on the orbit. (The Echo I experiment indicated that the pressure of sunlight on the 100-foot-diameter moon could, over a period of time, have an enormous effect on the satellite's orbit, pushing it downward by as much as a mile a year or more.)

In one approach, NASA scientists have tested materials consisting of fine wire mesh in waveguides[8] to determine reflectivity at 3 to 10 KMcps. The wire mesh was bonded to several transparent materials—including Teslar and Mylar films—to permit inflation and erection of the satellite. Exposure of these films to proton particle radiation equivalent to 1 year of exposure in the inner Van Allen radiation region did not cause any loss of transparency. Methods of erecting metallic mesh with the additional weight of plastic film are under study.

Impact of High-Speed Particles on Structures.—Research on this subject at Ames is being conducted with the aid of a Beckman-Whitly camera capable of making motion pictures with good resolution and clarity at rates of up to 1 million frames per second. Useful pictures have been obtained of a glass projectile traveling at speeds up to 20,000 feet per second (14,000 m.p.h.) and puncturing two aluminum sheets that have been spaced about 1 inch apart.

Picture quality is good enough to permit estimation of the speed of the particles produced by the impact; it also gives a qualitative idea of how completely the projectile is broken up. When initial impact is at relatively low rates, projectile particles may be seen to travel in a fairly compact group, clear through to impact against the second sheet. On the other hand, at higher speeds, the initial impact appears to be much more destructive to the projectile, and the particles traveling through to the second sheet are finer, and dispersed over a much larger area.

Structures Research

Flutter of Skin Panels

The increasing incidence of flutter[9] of the outer skin panels of hypersonic and entry vehicles has focused considerable attention on this phenomenon.

Preventing this type of flutter, or reducing it to safe levels, has become a significant factor in the design of several high-performance vehicles such as the X–15 experimental airplane, the Mercury capsule, and the Dyna-Soar vehicle.

Current theoretical methods for predicting panel flutter are inadequate; however, large test facilities are now available in which problems of panel flutter may be investigated experimentally.

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[8] Tubelike devices for conducting very-high-frequency electromagnetic energy from one point to another.

[9] "Flutter"—a rapid, irregular vibration produced by interaction of structural qualities—flexibility or rigidity—with weight distribution and aerodynamic forces.

At Langley, for example, many different types of panels have been tested and the results have been correlated and published (NASA TN D-451). The correlation shows—in terms of flight conditions (speed and altitude) and of panel size, shape, and stiffness—the point or boundary at which flutter starts. Other factors, however, such as pressure differences across the panel, the methods used to support the panel edges, and the effects of aerodynamic heating, must be considered separately.

The effects of aerodynamic heating on panel flutter have been investigated in the 9- by 6-foot thermal structures tunnel, using both general research panels and panels used in specific flight vehicles. (Among the latter were several panels and a vertical tail section from the X-15 experimental airplane.)

It has been shown that aerodynamic heating can cause a panel to become unstable and start to flutter; however, additional heating sometimes has the effect of eventually stopping flutter. Thus, the flight conditions at which flutter will occur depend strongly upon the level and duration of the aerodynamic heating encountered. Investigation of these phenomena is continuing, and the fundamental information obtained should aid in the design of safe, efficient outer skin panels for launch and entry vehicles.

In related experiments, a full-size quarter segment of the Centaur jettisonable [10] plastic heat shield was subjected to a series of tests, completed on December 16, 1960, which indicated that the proposed design should survive the conditions encountered during a Centaur launch.

Evaluation of Structural Panels.—One approach to the structural design of hypersonic aircraft consists of blocking off some of the severe aerodynamic heat with a heat shield and a layer of insulation, and then absorbing whatever heat that finds its way into the structure in (boiling) water. In this scheme, a system of "plumbing" is required to distribute the water coolant to the heated areas in the proper amounts to soak up the incoming heat. Since separate plumbing systems are ordinarily quite heavy, some means must be devised of keeping down the overall weight. One way of accomplishing this is to build a dual-purpose structure in which the plumbing system doubles as reinforcement to the load-carrying system, or the load-carrying system is internally designed to circulate the water through its structure without separate piping.

The Bell Aerosystems Co., of Buffalo, N.Y., has worked extensively with this latter scheme, and has developed so-called *tubed sheet* which consists of a sheet of structural material with a pattern of internal passageways in which a coolant under pressure can be circulated. The passageways are constructed on one side of the sheet,

[10] Designed to be dropped off or jettisoned once its purpose has been served.

leaving a plane surface on the other side to which stringers or stiffening members can be readily attached. Hence, tubed sheet can be used as the structural skin in an otherwise conventional arrangement.

Langley has completed tests of several types of panels constructed with tubed sheet. Fourteen shear panels and eight compression panels tested were of an alternate design in which the coolant passageways consisted of tubes brazed to one side of a conventional structural sheet to permit direct comparison of the two types of construction.

During the tests the coolant passages were pressurized, the load was applied, and measurements were made of the coolant flow and the deformation of the panels. The tests showed that the skin buckling was delayed somewhat by the presence of the coolant passageways, but that the maximum load the panels could support was essentially unchanged, with or without the passageways. When skin buckling became fairly severe, or at high loads, coolant flow was somewhat diminished; at the ultimate load, in the case of the shear panels, the flow was reduced to approximately half that present at the beginning of the test. It should be noted that the tests were under conditions considerably more severe than those that will be encountered under normal flight conditions. Hence, the panels would not ordinarily buckle in regular usage, and the coolant flow would accordingly not be reduced.

Detailed Wind Shear[11] Measurements

As launch vehicles become larger and larger, problems of atmospheric pressure effects grow constantly. In particular, the dynamic loadings resulting from the wind shears encountered at altitudes up through the region of maximum dynamic pressure, or "g," during launch can be extremely serious.

Available balloon-sounding data yield only a rough picture of the wind structure and are inadequate for detailed calculations of launch-vehicle response. A technique utilizing photogrammetric measurements of successive positions of the smoke or exhaust trail of an ascending launch vehicle has been developed by Langley as a means of obtaining a detailed and accurate wind profile over the needed altitude range.

The results obtained to date from tests at Wallops Station indicate that the wind field along a launch-vehicle trajectory is a random type of disturbance, with shear layers only 300 to 400 feet thick embedded in the previously recognized larger scale wind changes. A program is now underway to obtain a number of these measurements from firings at Wallops Station, and to extend this work to the Cape Canaveral area.

[11] High-altitude air currents moving in the same or different direction(s) at varying speeds.

Special Research Projects

Two Research Aircraft

X–15 and Dyna-Soar are the latest in a line of research aircraft which will span the flight range between supersonic and orbital velocities.

The rocket-powered X–15, with its 57,000-pound-thrust XLR–99 engine, is designed for speeds up to 4,000 m.p.h., altitudes up to 50 miles. The rocket-launched Dyna-Soar glider will be capable of soaring completely around the world at orbital velocities and altitudes. Like the X–15, Dyna-Soar will be capable of a degree of maneuverability in the fringes of the atmosphere and on reentry; it will also be able to land at conventional speeds of about 200 m.p.h. (Dyna-Soar is a contraction of the term dynamic soaring; that is, a method of flight employing both centrifugal force and aerodynamic lift.)

The X–15 is a joint Air Force-NASA-Navy project; Dyna-Soar is an Air Force program with NASA technical support.

This chapter outlines overall progress in the X–15 and Dyna-Soar projects.

The X–15 Research Airplane

The X–15 is sheathed in heat-treated Inconel X-nickel alloy to resist the 1,200° temperatures encountered at high speeds. A thin coat of black paint helps radiate heat as the aircraft reenters the atmosphere. Empty, the X–15 weighs 6½ tons; loaded with fuel, it weighs 15 tons.

During the report period, the X–15 repeatedly established new world speed and altitude records. As of June 30, 1961, the records stood as follows: 169,600 feet (32.12 miles) altitude, set on March 30, and 3,603 m.p.h. or Mach 5.3 set on June 23. Its pilots and its instruments also compiled masses of scientific and engineering data.

In each test, the flight routine is roughly the same. Suspended beneath the right wing of its B–52 mother ship, the X–15 is carried up from Edwards Air Force Base, Calif., to an altitude of about 45,000 feet over a 485-mile-long by 50-mile-wide flight range between Edwards Air Force Base and Wendover Air Force Base, Utah. The B–52 drop-launches the X–15 on a heading for Edwards.

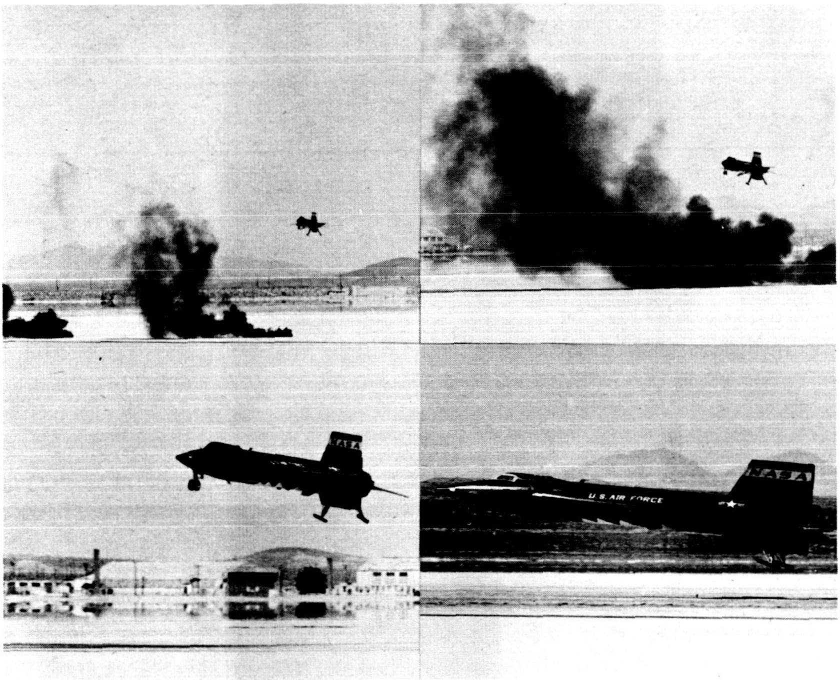
The X–15 pilot then ignites the rocket engine, and the aircraft heads upward in an arcing flight path. After the rocket engine cuts off, the aircraft coasts to peak altitude. The pilot then glides back to a skid landing on Rogers Dry Lake bed near Edwards. The flight range

NASA test pilot Joe Walker and the X–15

(called high range) is dotted with dry lake beds which serve as emergency landing fields. The range is monitored by stations at Wendover; Ely and Beatty, Nev.; and Edwards.

The objective of the X–15 program is to derive research information in flight at supersonic and hypersonic (faster than Mach 5) speeds in a space environment. Subjects for investigation include atmospheric exit and entry techniques, aerodynamic heating, navigation, landing, man's control handling capability, and his physiological reactions. The knowledge gained will be used in the design of future high-speed, high-altitude operational aircraft.

North American Aviation, Inc., Los Angeles, Calif., was the prime contractor.



An X–15 landing sequence—smoke bombs on the dry lakebed guide the pilot in landing

X–15 No. 2 Research Airplane

New XLR–99 Engine Flight Tested.—On November 15, 1960, North American Aviation test pilot Scott Crossfield made the first test flight with the new 57,000-pound-thrust XLR–99 engine. After an air-launch from the B–52 mother ship over Edwards, Crossfield took X–15 No. 2 to a speed of nearly 2,000 m.p.h. and an altitude of about 80,000 feet.

Restarted in Flight.—In a second flight on November 23, Crossfield stopped the XLR-99 engine in flight for 15 seconds, then started it again. After restarting, he gave the engine full throttle for the first time, achieving a speed of 1,700 m.p.h. (Mach 2.5) at 62,000 feet altitude.

During a third test flight on December 6 the engine was stopped and restarted two times. The test was the last of a series made by the contractor before turning X–15 No. 2 over to the Air Force and NASA on February 8, 1961.

Sets New Speed Record.—In the first flight to explore fully the characteristics and operating capability of the airplane, Maj. Robert M. White, USAF, piloted X–15 No. 2 to a new unofficial speed record of 2,905 m.p.h. on March 7, 1961. Released from the B–52 at 45,000 feet, the X–15 climbed to 76,000 feet, attaining the record speed at engine shutdown after 2 minutes 6 seconds of powered flight at 50-percent thrust. Portions of the X–15 were subjected to temperatures of nearly 675° F. (still well under the maximum design temperature 1200° F.). A liquid-nitrogen cooling system kept White's pressurized suit at a comfortable temperature.

Altitude Record Set.—On March 30, 1961, NASA research pilot Joseph A. Walker achieved a new unofficial record altitude for manned aircraft. After drop-launch, Walker held the X–15 in a 35° climb at three-quarters throttle for 79 seconds. He reached an altitude of 109,750 feet and a peak speed of 2,756 m.p.h. before cutting off the engine. The X–15 coasted for 60 seconds more to an altitude of 169,600 feet (32.12 miles). For about two minutes, Walker was weightless.

Space Controls Used.—At the apex of the flight, Walker found that his space controls—hydrogen peroxide jets in the nose and wings—could be used to orient the airplane along the ballistic track. Because the X–15 was above 99.97 percent of the earth's atmosphere, the effectiveness of the wing and tail aerodynamic control surfaces was greatly reduced.

Autopilot Caused Buffeting.—During the descent, the X–15 buffeted violently, but the vibrations, which Walker later said were the most violent he had ever felt, subsided in a few seconds. The vibrations were subsequently traced to the stability augmentation system, an autopilot device that aids in controlling the aircraft. The parts of the system responsible for the buffeting were replaced with improved components.

Speed Record Broken Repeatedly.—On the third powered flight with the Thiokol Reaction Motors XLR–99 engine on April 21, Major White piloted X–15 No. 2 to a speed of 3,074 m.p.h. (Mach 4.6).

After the X–15 was drop-launched at 45,000 feet, its rocket engine cut off. The airplane fell to 37,000 feet in the 30 seconds it took to restart the engine.

After 67 seconds of flight at full 57,000 pounds thrust, the X–15 climbed to 80,000 feet, setting the new speed record at that altitude. Momentum carried the airplane to 103,000 feet, where White experienced weightlessness for about 1 minute.

During the coast-to-peak altitude, a leak caused cabin pressure to fall, but Major White's space suit compensated for the pressure loss.

An X–15 mission starts with takeoff from Edwards Air Force Base, Calif. The research aircraft is carried under the right wing of the B–52

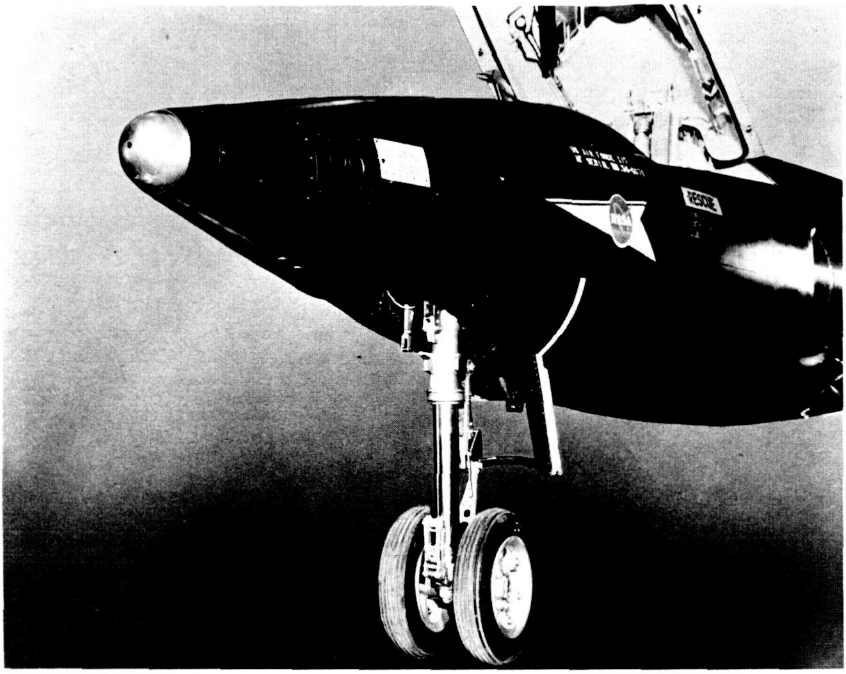
On May 25, NASA pilot Walker, using the full thrust of the XLR–99 engine, piloted the research aircraft to 3,307 m.p.h. (Mach 5) in 73 seconds of powered flight. Parts of the vehicle's structure reached temperatures up to 700° F.

On June 23, Major White flew the X–15 at 3,603 m.p.h. (Mach 5.3) or 1 mile a second. The flight lasted 11 minutes—75 seconds of it at full power—and the X–15 reached an altitude of about 100,000 feet. The airplane encountered temperatures up to 830° F. during the flight, and as it descended the heat of friction stripped away painted lettering on the aircraft and charred the fuselage paint.

X–15 No. 1

New Nose Sensor Tested.—On December 9, 1960, NASA research pilot Neil Armstrong made the first flight test of X–15 No. 1 with a new sensor nose device developed by Northrop Corp., Beverly Hills, Calif., under NASA contract. The aircraft was powered by a pair of interim 8,000-pound-thrust Thiokol Reaction Motors engines.

Replacing the long, needlelike radio antenna used in all previous X–15 flights, the new ball-shaped sensor nose is designed to sense the angle of attack and sideslip when the aircraft is leaving or entering



The X–15 with the new ball-shaped sensor nose

the upper atmosphere. Accurate sensing is necessary to prevent the aircraft from reentering the atmospheric at too sharp an angle; if the angle is not precise, friction at hypersonic speeds—up to 4,000 m.p.h.—would burn up the plane.

Final Engine Installed.—NASA and the Air Force returned X–15 No. 1 to the contractor in February 1961. North American installed the final engine, the 57,000-pound thrust XLR–99, and delivered the aircraft to NASA's Flight Research Center at Edwards.

X–15 No. 3

Repairs Continued on Schedule.—After being heavily damaged on June 8, 1960, by the explosion of its XLR–99 engine during ground testing, X–15 No. 3 is being rebuilt by North American at an estimated cost of $4 million. The contractor is installing research equipment and a "black box" control system different from that in X–15 Nos. 1 and 2. Delivery of the airplane to NASA and the Air Force is expected in late 1961.

Other X–15 Results and Objectives

Physiological Data Collected.—Studies of pilot reactions to conditions encountered during X–15 flights—useful in establishing standards for pilots of high-performance aircraft—show that peak heart and respiration rates occur at launch, burnout, and landing. The heart and the respiration rates were found to vary widely among pilots, but in all cases both rates decreased significantly on a pilot's second flight.

The X–15 is also being used to obtain aeromedical data on radiation instrumentation. It carries radiation counters surrounded by "tissue-equivalent material" and blocks of photographic emulsion. NASA investigators can receive and interpret telemetered data from the airborne instruments, and they can also use this information for subsequent checking on data collected by recording instruments during the flight.

Further research and evaluation of data collected earlier also continued in these major research areas: Flight control at very high altitude, atmospheric exit and entry techniques, terminal guidance, and landing-gear research.

Support of Dyna-Soar Program

Rocket-Boosted Glider in Concept Stage

Two principal contractors and many associated contractors and subcontractors are developing and producing Dyna-Soar. The Boeing Co., Seattle, Wash., is contractor for design and production of the rocket-boosted glider and for overall system integration; the Martin Co., Baltimore, Md., is prime contractor for the modified Titan boosters.

Under a 1958 agreement with the Air Force, NASA has been providing technical research assistance in all aspects of the Dyna-Soar project. At NASA research centers, about 55 individuals have been working on the project full time.

Stability and Control Investigated.—The glider configuration was defined and methods of refining it have been investigated. During the report period, Langley and Ames Research Centers and the Jet Propulsion Laboratory (JPL) made tests to refine the aerodynamic stability and control characteristics at speeds up to Mach 18.

Also at Ames, measurements were made to determine the air pressures on the glider and the effectiveness of the control surfaces at transonic and supersonic speeds. Tests were also conducted to determine the air pressures on the complete launch vehicle—glider mounted on Titan booster.

Aerodynamic Heating Studies.—At Langley and JPL, heat transfer measurements made on the complete launch vehicle and on the Dyna-Soar glider alone determined the heat loads and critical regions of high aerodynamic heating. Tests on flutter characteristics begun earlier at Langley and Ames were continued. In future testing, the effects of added heat, simulating flight temperatures, will be investigated.

Mockup Being Readied.—At the Boeing plant, work on the Dyna-Soar mockup continued in preparation for a September 1961 inspection and evaluation.

Life Science Programs

Objectives

NASA's Office of Life Science Programs[1] has three major objectives: (1) To support manned space flight; (2) to study the effects of the space environment on living organisms, including a search to determine whether life exists elsewhere in the universe; and (3) to investigate advanced concepts in biological science.

In support of these objectives, studies are under way to learn how living organisms are affected by radiation, weightlessness, acceleration, confinement, and numerous other stresses. In addition to launching an extensive contractual program, NASA is stimulating and supporting work in these areas elsewhere in Government, and in educational and industrial organizations. The Agency has also organized a Life Sciences Research Facility at Ames Research Center (Mountain View, Calif.), and has instituted a postgraduate fellowship research program there.

Support of Manned Space Flight

Extensive research and development contracts and grants in the life sciences as related to manned space flight are outlined in the following paragraphs, and listed in appendixes I and J of this report.

Radiobiology

Physical measurements of the Van Allen radiation regions and the space beyond emphasize the need for (1) obtaining a better understanding of the effects of longterm, relatively low doses of ionizing radiation, and (2) devising ways of protecting against this radiation. Accordingly, NASA is sponsoring and conducting research into the relation of simulated space radiation to survival, growth, performance, and genetics of animals in ground-based experiments. Related work is determining the effects of simulated cosmic radiation on whole body, organs, and systems.

[1] Divided after the report period into Bioscience Programs (Office of Space Sciences) and Aerospace Medicine (Office of Manned Space Flight).

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Further, the Agency plans using a Scout or Delta launch vehicle with a nose cone modified by the General Electric Co. to carry biological material (Project BIOS[2]) into the lower Van Allen radiation regions to an altitude of about 2,300 miles. The vehicle will be in a condition of "near" weightlessness (about 0.01 g) for more than 55 minutes. Test forms to be carried will include: Spores of bread mold; a microscopic organism normally found in the intestines that aids in the digestive process; whole blood; barley seeds; and grasshopper embryos—all to be used in studying the genetic and lethal effects of ionizing radiation.

Other work will be aimed at learning more about the interaction of ionizing radiation and (by means of laboratory simulation) combined stresses of space flight such as acceleration, temperature, lowered atmospheric pressure, and fatigue.

Investigations are being planned with the aim of devising means of shielding the astronaut against harmful doses of radiation. At the same time, instruments are being designed to measure levels of exposure by testing living biological specimens that have been subjected to such radiation.

Metabolism

When men or animals are confined to the restricted environment of a space capsule, many of their life processes may be profoundly affected. For this reason, NASA is sponsoring the following research into various artificially-induced changes in living cells and entire organisms, as well as alterations in vital processes and activities:

... The influence of simulated weightlessness and other space-flight conditions on human beings and animals.

... Studies into lowering the temperature of the human body from a normal 98.6° F. to between 68° and 82° F. for a long period of suspended animation; also, related research into hibernation in animals for protection against radiation injury, and to conserve food and energy. (This "icebox" technique is now being used as anesthesia in certain types of surgery.)

... The problems of nutrition, digestion, and excretion in long-term isolation and confinement.

Circulatory System

Under investigation are the fundamental physical changes in animal and man resulting from acceleration forces and weightlessness, and the consequent redistribution of blood flow to the heart, lungs, brain, and kidneys. (The "blackouts" experienced by jet pilots when acceler-

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[2] Project BIOS is further reviewed under "Biological Programs," p. 135.

ation forces reduced the normal delivery of blood to the brain are a familiar example of this physiological hazard.)

The chronic effects that physical stresses have on vital organs, the way the organs adapt to such stresses, as well as the long-term effects of restricted movements on the circulatory and related systems need to be understood by scientists. Accordingly, research in these areas now includes studies of (1) blood flow during acceleration stress and partially simulated weightlessness, (2) the adaptation of the circulatory system to long-term immobilization, and (3) the effects on blood vessels of the prolonged stresses of space travel.

Nervous System

During weightlessness, the inner ear and related organs of balance and orientation may produce misleading or disturbing sensations. For example, subjects experiencing subgravity while unrestrained have frequently become nauseated or frankly scared.

Paralleling human reactions, mice have been less disturbed when they had something to cling to. These reactions demonstrate a need for greater knowledge of the stresses of simulated space flight on the nervous system of whole organisms. Accordingly NASA's scientists are exploring—

(1) the effects of fatigue and other prolonged stresses on the brain and nervous system;

(2) the response of delicate ear mechanisms, the eye, and the sense of touch, as well as the astronaut's adaptability to stresses, including rotation and weightlessness;

(3) the use of special drugs to maintain the normal activities of the nervous system in space flight; and

(4) the response of the nervous system to alteration of the night-day cycle.

Stress Tolerance and Protective Equipment

Research is underway into each stress factor, the combined stress factors to be simulated later in earth-orbiting laboratories. These studies should aid in protecting man against his stress-tolerance limitations, by (1) placing control and instrument panel displays to be read easily and providing adequate measurement of human performance in space flight; (2) developing miniature telemetering equipment and sensors to measure brain waves, blood pressure, etc.; and (3) evaluating human tolerance to high- and low-grade, long-term acceleration patterns.

Musculoskeletal System

Animal and human musculoskeletal-system responses to the acceleration forces of air and space flight are under investigation, as are efficient restraint systems and contoured positioning and control devices relating to man's tolerance to and performance in space flight. Research is also underway on the effects of acceleration and weightlessness on the musculoskeletal systems in periods of transition into and out of the weightless state.

Psychological Reactions

The psychological reactions interrelated with motivation, vigilance, anxiety, confinement, and social adjustment in general under space-flight conditions are being scrutinized. For example, the "breakoff" reactions of pilots of high-altitude aircraft who feel a false freedom from earthbound ties are well known, as are the "raptures of the deep" experienced by deep-sea divers.

Studies also enter into effects of isolation, confinement, social deprivation, fatigue, and other stresses on the astronaut; psychological interactions between members of small isolated groups in hazardous situations, psychological aspects of motivation, vigilance, and fatigue; and psychosocial problems associated with rapid advances in science and technology.

"Man-Machine Integration" and Instrumentation

Studies to insure "man-machine" compatibility in space vehicles bear out previously announced findings that automatic controls and instrumentation alone cannot successfully complete an advanced manned space mission. A man is essential—to observe, analyze, and make decisions when confronted with problems. He is flexible enough to operate, correct, and maintain scientific instruments and equipment as he must in flying an aircraft. However, improved physical sensors, information displays, and ground-control integration also contribute to man's increased effectiveness with remotely operating unmanned vehicles; in devising sample collecting and analyzing devices for biological investigations, and in supporting experiments in the physical sciences. Projects in this area include—

(1) studies of animal and other biological sensory systems to determine the possibility of designing instruments to work on the same general principles;

(2) studies to determine the types of information needed to operate remotely located manipulators; and

(3) experimental and theoretical research into man's ability to perform tasks of varying complexity by using remotely

located equipment when information about the location and status of such equipment is delayed over various periods of time.

Instrumentation, Displays and Control Systems.—To establish and maintain an adequate man-machine relationship, the astronaut or the crew must always be aware of the total situation, even in a vehicle that is largely automatic. For this reason, continuous or repeated information must be provided about the conditions of the spacecraft; data must be supplied on time, velocity, distance, course, power, and fuel supply. Such information must be immediate and reliable, with a minimal possibility of introducing human error in reception and interpretation.

Studies underway involve man's capacity to build remotely controlled space-vehicle systems and similar systems. Only by knowing how an operator uses his hands and eyes, and by anticipating his responses under the various stresses and strains unique to the space environment, can scientists determine the physical rules and devise the mathematical equations describing the transfer function of the human operator.

Manmade Atmospheres.—When man goes into space he will have to carry his own atmosphere with him, including an adequate oxygen supply. The manmade atmosphere must provide a tolerable living area for a predetermined period of time. Carbon dioxide and other noxious gases must be carefully controlled in the limited environment of a space capsule. NASA is attempting to create through bioengineering a private little world (that is, a closed ecological system) by using a biological system such as algae to produce oxygen, food, and water from the astronaut's waste products.

Space Biology

Space biology is concerned with:

. . . Studying the effects of extraterrestrial environments on living earth organisms.

. . . Determining whether any organic chemical life-supporting compounds exist in extraterrestrial space or on the Moon, Mars, or Venus.

. . . Developing means of remote identification and analysis of possible extraterrestrial life forms or even organic particulate matter; at the same time preventing the extraterrestrial bodies from becoming contaminated by organic chemicals or microbiological forms from the earth through careful sterilization of spacecraft and components.

To carry out this program, NASA sponsors research and development work with other Government agencies, educational institutions, and industrial organizations. The Agency also conducts a flight program and sponsors a Space Biology Institute at Florida State University (Tallahassee).

Further, the National Academy of Sciences administers a fellowship program for NASA designed to place junior and senior postdoctoral scientists in NASA centers for research and training in the space life sciences.

Space Biology Projects

Decontamination of Spacecraft.—NASA is exploring: (1) Degree of natural contamination of spacecraft components; (2) selection and use of various sterilants; and (3) resistance of micro-organisms to the space environment.

Analysis of Meteorites.—Recent results from the biological analysis of meteorites showed carbonaceous compounds, paraffinoid substances, and slow-growing bacteria. As a preliminary to planetary landings and infrared spectroscopic observations from high altitude platforms and planetary orbiters, meteoritic analysis affords an excellent approach in studying extraterrestrial life.

Exotic Environment.—At present this work involves the effects of zero magnetism, low atmospheric pressure, and various gases on animals and plants.

Extraterrestrial Life.—Among the theoretical studies of extraterrestrial life are—

(1) development of models of primitive metabolic systems and analysis of extinct metabolic analogs;

(2) the accumulation and collation of material on primitive protoplasmic systems;

(3) conclusions regarding the nature of life forms beyond the earth; and

(4) methods of detecting life based on nonterrestrial principles, and of low concentrations of life or organic material.

Experiments in Space Environmental Biology.—NASA is exploring the effects of the space environment on biological processes and considering the use of space as a vast laboratory for studying fundamental biological phenomena. As preliminary steps, some ground-based experiments are being conducted on two of the foremost barriers to space travel—radiation and weightlessness. Experimental prototypes of an earth-orbiting, recoverable biological satellite are planned.

Biological Systems in Space and Planetary Environments.—A biophysical research program of biological systems in the interplanetary environment is composed of three main areas of study—

(1) the physical chemistry of the effects of weightlessness on heat transfer and convection in fluid systems—at present limited to ground-based control studies;

(2) capillary growth chambers for in-flight measurement of cell proliferation under weightless conditions; and

(3) space research studies with the flour beetle (Tribolium), because of its unusual response to radiation and temperature variations.

Instruments to Detect Extraterrestrial Life.—NASA is attempting to perfect instruments capable of detecting extraterrestrial life on relatively nearby planets such as Mars. The design and development of a high-resolution vidicon (TV) microscope is an example.

Institute for Space Biology.—The Institute for Space Biology (Florida State University, Tallahassee) was established by NASA to gather knowledge, generate new research, and review and solve fundamental scientific problems in space biology. The Institute will use biological systems to (1) measure space environmental effects, (2) search for the prebiological basis of life, and (3) employ space in the study of fundamental biological problems.

The laboratory is similar to those sponsored by the U.S. Atomic Energy Commission on university campuses. The staff consists of astronomers, biochemists, and experimental biologists, along with geneticists and specialists in the fields of photosynthesis, radiobiology, microbiology, astrobiology, and geochemistry.

Biological Programs

NASA's biological space flight program is briefly reviewed below.

Project BIOS (Biological Investigations of Outer Space) will involve trajectory flights into the lower Van Allen radiation belt to measure the extent and intensity of radiation in initiating genetic changes, and to observe the effects of near zero gravity on fertilization and cell division.

A study of Project BIOS includes the use of sea urchin eggs and sperm. The eggs will be fertilized with the sperm during the near-weightless phase of the journey, to test the motility of sperm and cell division. Laboratories in this project include the Goddard Space Flight Center, Ames Research Center, Oak Ridge National Laboratory of the U.S. Atomic Energy Commission, and Florida State University.

Another flight experiment will use infrared spectroscopy to detect life-related compounds and study the composition of planetary atmospheres. The spectroscope will be carried by a balloon to a high altitude and pointed toward the selected planet to determine if it has an atmosphere and then to identify the organic constituents on the planet. Similar data will be gathered on various types of terrain on the Earth, for example, desert, green field, lava beds, etc.

Further studies are in progress to determine ways in which knowledge gained through animal experiments in weightlessness, acceleration, radiation, etc., may be of value in NASA flight programs to reduce these hazards for flight crews.

Project Mercury

Initiated in October 1958, as the Nation's first venture into manned space, Project Mercury is planned to determine man's capacity to adjust to the stresses of space and return to his normal environment. To accomplish this scientific objective of orbiting and safely recovering a manned spacecraft, the existing Redstone rocket—with certain design modifications—was used in the May–July 1961 suborbital flights in the interests of speed, efficiency, and economy.

Mercury astronauts Shepard and Grissom while preparing for these trajectory flights have provided biomedical information helpful for further planning. Their training has also afforded insight into necessary changes and additions to the physical conditioning procedures for future astronauts.

Preparations for Suborbital Flights

A major area of preparation for Naval Commander Alan B. Shepard, Jr.'s flight of May 5 concerned the biomedical readiness of the astronaut and the testing of the life support systems. While the astronauts were being trained, a parallel program using animals for qualification of the support system was begun and carried through. This program reached its culmination with the suborbital flight of chimpanzee "Ham" on January 31, 1961. The chimpanzee bore the flight stresses well and continued to perform on the psychomotor testing apparatus, except during the peak accelerations associated with firing of the escape tower and reentry.

Shepard's Flight

Commander Shepard's biomedical preparation consisted of thorough instruction in the physiology of the human body to help him understand the effects of flight stresses and thereby enable him to report better on these effects, and extensive testing and training in the dynamics of the flight, with repetitive experiences under simulated flight conditions.

The astronaut received exhaustive physical examinations before and after the flight. A preflight examination showed him to be relaxed, cheerful, and in good health, with all findings consistent with those of previous examinations. Psychiatric examination indicated he was alert and had abundant energy and enthusiasm.

Examinations on Grand Bahama Island several hours after recovery produced the report that Shepard ". . . seemed quietly elated and offered no complaints," and that he "... felt calm and self-possessed."

An excerpt from a portion of the official report of his post-flight checkup follows: "He was more concerned about performing effectively than about external dangers. He reported moderate apprehension during the preflight period, which was consciously controlled by focusing his thoughts on technical details of his job. As a result, he felt very little anxiety during the immediate prelaunch period. After launch, he was preoccupied with his duties and felt concern only when he fell behind in one of his tasks. There were no unusual sensations regarding weightlessness, isolation, or separation from the earth. Again no abnormalities of thought or impairment of intellectual functions were noted."

Post-flight medical examinations revealed no significant changes in the astronaut's physical condition as a result of the flight. Electrocardiogram, electroencephalogram, and chest X-rays were normal. A number of changes were noted in body weight, temperature, respiration rate, blood pressure, and pulse rate at rest and before and after exercise. These were expected, and fell within normal ranges.

Shepard maintained a pulse rate of about 80 beats per minute during the prelaunch countdown with brief rises to 90–95 during significant spacecraft checkout events. Pulse rate rose to 108 about a half minute before liftoff, was 126 at liftoff and reached a peak of 138 at the time of cutoff of the launch-vehicle engine and subsequent separation of capsule and booster system. This elevated rate was sustained for about 45 seconds. The pulse rate was erratic during the weightless interval, falling to 108 just prior to reentry. A second peak, of 132, occurred about 30 seconds after maximum reentry acceleration, and during descent the rate fluctuated between 130 and 108 per minute.

The astronaut's respiration rate remained generally between 15 and 20 breaths per minute during the prelaunch phase and reached a peak of 40 per minute during the launch and powered phase of the flight. This fell to 20 per minute near the end of the weightless period. It rose again during reentry accelerations to a high of 30, and fluctuated between 20 and 25 breaths per minute during the descent. Electrocardiogram traces showed no significant abnormalities throughout the countdown and flight. Deep body temperatures varied from 99° F. when Shepard first entered the capsule to 99.2° F. near the end of the flight.

A report by NASA's physicians concludes that—

(1) physiological responses were consistent with intact conscious performance during all phases of the flight;

(2) physiological responses to 5 minutes of weightless flight (interrupted by 23 seconds of retrofire) were uneventful;

(3) acceleration-weightlessness transition periods produced physiological responses within the limits of intact function, and the relative change in pulse rate in going from weightlessness to reentry acceleration was comparable to that in going from one g to reentry acceleration previously experienced on a human centrifuge; and

(4) special senses—vision, semicircular canal function, and hearing—appeared intact throughout the flight.

Construction of Facilities

Expenditures

Between October 1, 1960 and June 30, 1961, NASA expenditures on construction and equipment totaled $72,929,000 for the following principal projects:

Ames Research Center, Mountain View, Calif.

Wind Tunnels in Operation

During the report period the 3.5-foot hypersonic wind tunnel and the 12-inch hypersonic helium wind tunnel, noted in the Agency's fourth semiannual report to Congress, went into operation. The first facility was constructed for an estimated $11 million; the helium wind tunnel for an estimated $1,585,000.

Hypervelocity Research Laboratory

This facility—completed at an estimated cost of $1,145,000—will investigate the fundamental physical and chemical problems of hypervelocity flight and space operations and research.

An X-ray spectrometer, an electron paramagnetic spectrometer, an electron microscope, and a mass spectrometer have been installed at the laboratory. A shock tube is the only major part of the project to be completed.

Flight Research Laboratory Modified

Electronic analog equipment and a three-degree-of-freedom motion simulator were installed and put in operation during the reporting period. A five-degree-of-freedom motion simulator and a centrifuge were installed and shakedown operation of the centrifuge started. A stationary transport-airplane flight simulator was also put into use. Estimated cost for these modifications is $990,000.

A new building to house a center for data processing and solving complex theoretical problems neared completion and is scheduled for occupancy in July 1961. Estimated cost is $2,305,000.

Mass Transfer Cooling and Aerodynamic Facility

In January 1961, NASA started construction of a wind tunnel capable of simulating on models the heating rates and aerodynamic buffeting experienced by spacecraft during steep entry into the atmosphere. The facility—expected to be in operation early in 1962—will cost an estimated $4 million.

Centrifuge Facility Equipment

Ames contracted for additional electronic analog equipment, in December 1960, at an estimated cost of $980,000.

Air-Removal System for Transonic Wind Tunnel

Larger models of aircraft can be tested at higher angles of attack since an air-removal system for a 2-foot transonic wind tunnel was built and installed. Estimated cost for the system is $437,000.

Flight Research Center, Edwards, Calif.

Terminal Guidance and Data Facility

This facility—designed as a microwave link for transmitting X–15 flight data to the Flight Research Center—was about 90 percent complete at the end of the report period. The microwave transmission system was in the checkout phase. Estimated cost of the research facility is $1,425,000.

Jet Propulsion Laboratory, Pasadena, Calif.

Laboratory and Engineering Facilities

The plant services building, vehicle assembly building, guidance laboratory annex, and an addition to the administrative services building were completed at a total cost of about $3 million. Three adjoining plots of land of about 70 acres were acquired at a cost of $400,000. Work continued on an environmental test laboratory, a space simulator, and an antenna range. Construction of the central engineering building was begun.

Langley Research Center, Hampton, Va.

Hypersonic Continuous-Flow Facility

Construction continued on a continuous-flow, hypersonic tunnel, operating at Mach 10 and 12 by means of two interchangeable nozzles; completion is scheduled for late 1961. The facility will cost $6,360,000.

Internal Flow Laboratory Improved

Work on improvements to increase storage pressure to 600 p.s.i. at the tank farm of the Thermal Structures Laboratory continued during the report period. Scheduled for completion late in 1961, this improvement will cost an estimated $808,000.

Hypersonic Physics Test Area

Several experimental facilities and units for storing high explosives, fuels, and oxidants to test materials and structural arrangements for hypersonic flight rockets are about 85 percent completed. They are expected to be finished early in 1962, at an estimated cost of $2,045,000.

Data Reduction Center

Built and equipped during this reporting period (except for some minor items), this 41,000-square-foot building houses all data reduction, processing, and analysis facilities. Estimated cost is $2,759,000.

Hypersonic Helium Blowdown Tunnel

A 22-inch blowdown tunnel able to duplicate the Mach 20 velocity attained by missiles, satellites, and vehicles entering the atmosphere from space has been completed except for a few minor items. Estimated cost for the tunnel is $997,000. (A blowdown tunnel is a wind tunnel where stored compressed air or other gas is allowed to expand in a stream through a section in which models are placed.)

High-Temperature Wind Tunnel

Office and laboratory buildings for an 8-foot, high-temperature, blowdown wind tunnel were completed. This tunnel will simulate the aerodynamic heating and loading of hypersonic aircraft. Auxiliary buildings for this facility are scheduled for completion early in fiscal year 1962. The project's estimated cost is $10,041,000.

Alterations to Thermal Structures Tunnel

Changes to improve the range and performance of this 9- by 6-foot tunnel will include adding a 100-foot-long diffuser, altering heat-barrier doors, improving the nozzle cooling system, and installing isolation valves. These improvements will allow test models to be subjected to less severe transonic flow conditions during startup and shutdown. The work moved forward during the report period and is expected to be completed early in 1962 at an estimated cost of $430,000.

Noise Research Laboratory

Work continued on a gust tunnel being modified to a noise research chamber. It will be used in making noise studies on materials and rocket engine models. Scheduled to be in operation in late 1961, the laboratory will cost an estimated $315,000.

High-Intensity-Noise Test Facility

A test cell is being modified to serve as a facility for research on the effects of high-intensity noises on structures and equipment. Added equipment includes a hot-air jet that will produce noise of random spectrum at a level of 170 decibels, and a siren that will produce a discrete frequency noise. The work is expected to be completed early in 1962, at an estimated cost of $290,000.

Air Heater for Hypersonic Jet Facilities

Installation of an air heater system in the 20-inch jet facilities continued, with completion scheduled early in 1962. Improvements will raise the air temperature from 1,050° F. to about 1,500° F. in the 20-inch Mach 8.5 tunnel, and provide a vacuum vessel for the Mach 1.5, 4.5, and Mach 6 20-inch hypersonic jet facilities. This will be a $355,000 project.

Hypersonic Aerothermal Dynamics Facility

Construction continued on helium and air hypersonic systems to simulate environmental conditions encountered by vehicles entering the earth's atmosphere from orbital or space flights. Critical aerodyamic and structural problems that occur at the high-entry temperatures and velocities will be studied in this facility, estimated to cost $7,957,000.

Dynamics Research Laboratory

Construction awards were made during this reporting period for a vacuum sphere, a vacuum cylinder with acceleration-test machine, vacuum pumping equipment, shakers, shock-testing machine, related instrumentation, and a building to house a dynamics research laboratory. This laboratory will be used to study the structural and free-body dynamics of space vehicles and components under simulated flight conditions. The $4 million project, except for the vacuum sphere, is scheduled for completion late in 1962.

Lewis Research Center, Cleveland, Ohio

Energy Conversion Laboratory

A laboratory for use in studying methods of converting energy to power for space flight was being built and equipped; it will cost $4,540,000.

Basic Materials Research Laboratory

The materials problems of space vehicles will be studied in a laboratory now under construction. The laboratory and equipment will cost $4 million.

Space Power Generation Systems Research Facilities

A Space Radiator-Condenser Research Facility to investigate heat rejection systems for turbogenerator and thermionic powerplants using alkali liquid metals, and a Power Conversion Systems Research Center to study power conversion systems, were being constructed at a total cost of $1,050,000.

Goddard Space Flight Center, Greenbelt, Md.

The central flight control and range operations building (Building No. 3) was completed at an approximate cost of $2.5 million. This building houses equipment to collect and process data from NASA tracking systems; it also provides laboratories for research and development of tracking and telemetry system components.

Three connected buildings (central boiler and chilled water plant, service shops and warehouse building, and an office building) were completed in October 1960. The boiler plant will be able to service any facilities added through fiscal year 1964.

Goddard Space Flight Center, Greenbelt, Md.

Marshall Space Flight Center, Huntsville, Ala.

Static Test Facility

Design of the static test stand for the first stage of the advanced Saturn vehicle was started; the facility will include test stand, blockhouse, instrumentation, and related equipment for a complete unit. Contracts were let for excavation and for fabricating instruments.

Central Laboratory and Office

A $4.4 million, nine-story office building was designed. It will serve as headquarters for the staff of MSFC and for various supporting elements.

Pressure Test Cell Building

In November 1960, work started on a building to house equipment for pressure testing the Saturn booster and components. Scheduled for completion by August 1961, the facility will replace present installations considered unsafe for required quality assurance tests.

Assembly Building Addition

As reported in the fourth semiannual report to Congress, 76,600 square feet of floor area are being added to the missile assembly building to permit assembling several Saturns at a time. These additions, costing about $2.5 million, are now 25 percent complete, with occupancy scheduled for February 1962.

Other Projects

In May 1961, design was completed and a contract awarded for an addition of 44,000 square feet to the engineering building. The addition—scheduled to be finished in June 1962—will cost about $1,137,000.

During the report period, design was completed and excavation started on an addition of 110,000 square feet to the checkout building. This work, costing $4,500,000, is 75 percent complete.

A 28-story, 310-foot gantry rises behind the blockhouse. This is one of two Saturn launch sites under construction at Cape Canaveral

Atlantic Missile Range, Cape Canaveral, Fla.

Saturn Launch Facilities

Additional construction, modifications, and instrumentation at Cape Canaveral will complete Saturn launch complex 34. These additions costing $2,207,000 will facilitate any future modifications required.

In January 1961, the design was completed for an escape system to enable personnel to leave the 30-story launch tower rapidly. Bids for this emergency exit system exceeded allowed costs and were rejected.

A second completely independent Saturn launch complex (No. 37) is under construction at the Atlantic Missile Range. Backing up launch complex 34, the new facility will serve as an alternate in case of destruction or modernization, and it will also allow increased launching rates. Construction continued on the present phase of complex 37, with completion scheduled for October 1962. Additional phases in succeeding fiscal years will permit expansion of this complex to launch the advanced Saturn.

Final design of the special assembly building for Saturn was completed in June 1961. The building—scheduled for completion during 1962, at a cost of $1,625,000—will contain laboratory space and complete checkout facilities for subassemblies and individual stages.

Centaur Launch Facilities

On March 1, 1961, Centaur launch complex 36 was activated at Cape Canaveral and turned over to project management.

The complex consists of an improved Atlas launch stand with an added liquid hydrogen facility to service the Centaur stage. The elevated launch stand is approached by a sloping two-story-high ramp with a water-cooled flame deflector beneath. The area below the ramp provides space for an instrumentation room, equipment mezzanine, toolroom, and general utility areas.

Next to the launcher (on the launch stand) is a 70-foot-high umbilical mast, supporting service lines leading to the Centaur second stage. Services include fuel, oxidizer, electrical and pneumatic power, instrumentation, control, and air-conditioning connections. Two hydraulically operated umbilical booms are fitted to support and retract Centaur disconnects.

The service tower is 173 feet high, with a 40- by 70-foot base; it contains retractable work platforms and two hoists—a 32-ton hoist at a lower level for erecting the booster, and a 20-ton hoist at the top for erecting the second stage and spacecraft. The entire self-propelled structure moves back 300 feet before lift-off.

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The blockhouse, a heavily reinforced concrete structure 800 feet from the launch stand, has a wall which varies in thickness from 12 feet at the base to 5 feet at the peak of the dome.

Storage capacity for 38,000 gallons of liquid oxygen is provided in two vacuum-jacketed tanks, together with associated pumping and transfer equipment; a first-stage fuel (kerosene) tank has a 14,500-gallon capacity.

Additional storage and transfer capacities are provided for 28,000 gallons of liquid hydrogen, 30,000 gallons of liquid nitrogen, 700 cubic feet of high-pressure gaseous helium, and 700 cubic feet of high-pressure gaseous nitrogen.

Wallops Station, Va.

Long-Range Radar

In June 1961, the long-range S-band radar (2,500-megacycle range) began operating. The facility—costing an estimated $2,250,000—will track final and near-final stages of rockets as small as 6 feet long and only several inches in diameter.

TIROS Read-Out Station

During this report period, Wallops Station replaced the Army's installation at Fort Monmouth, N.J., as the prime east-coast read-out station for tracking TIROS weather satellites.

Two medium-gain auto-track antennas for data acquisition, an auto-track system for the high-gain antenna manufactured by General Bronze Electronics Corp., Garden City, N.Y., a new 108-mc. acquisition antenna, along with the RCA ground station, were completed to permit this replacement. Estimated cost for the read-out station, including the antenna system, is $725,000.

International Programs

Worldwide Cooperation

The National Aeronautics and Space Act of 1958, which established NASA, stipulated that the fruits of the new agency's research and development would be made available to other nations "for the benefit of all mankind." The Office of International Programs, in cooperation with the U.S. Department of State, carries out this requirement in a variety of ways—through cooperative space projects; operations support activities; international fellowships and training; and participation in international space science and technology meetings.

Tracking Network Negotiations

Agreements Signed for Tracking Stations

The United States and the United Kingdom signed formal agreements for the establishment of three Project Mercury tracking and data-acquisition stations—on the islands of Zanzibar (October 14, 1960), Bermuda (March 15, 1961), and Canton (April 6, 1961)—and one Minitrack station at Winkfield, England (January 20, 1961).

The Governments of Nigeria and the United States signed a formal agreement for the establishment of a Project Mercury station at Kano, Nigeria (October 19, 1960). Agreements for all other NASA tracking stations were signed before the period covered by this report.

Mercury Tracking Stations Dedicated.—Project Mercury tracking stations were dedicated at Woomera and Perth, Australia; Guaymas, Mexico; Bermuda; and Kano, Nigeria, during the report period.

Interagency Tracking Arrangement

An interagency arrangement was reached in December 1960 between NASA and the Radio Research Laboratories (RRL) of the Japanese Ministry of Communications. Under the terms of this agreement, RRL will retain and use NASA telemetry equipment at

Toyokawa, Japan, subject to priority requirements of NASA. The equipment had originally been provided by NASA in connection with a research grant for RRL to acquire data from the Explorer VII satellite. RRL completed their work on this project in November 1961.

Dedication of Woomera Deep-Space Station

On February 10, 1961, Dr. Hugh L. Dryden, NASA Deputy Administrator, communicated via the moon with the Honorable Alan Hulme, Australian Minister of Supply, as part of the dedication ceremonies for the newly completed deep-space tracking station at Woomera, Australia. Dr. Dryden telephoned from Washington, D.C., to the deep-space tracking station at Goldstone, Calif., which relayed his message by radio to the moon. The reflected signals were then received by the Woomera Station, about 8,000 miles from Goldstone. ("Moon Bounce" messages have been transmitted before, but never between such widely separated points.)

Personnel Exchanges

NASA facilities were visited by 518 foreign nationals during the report period. Among the visitors were a Japanese space science survey team; the Chairman and representatives of the French Committee on Space Research; a special mission from Canada interested in meteorology and communications satellites; and members of space research committees (or of groups interested in space research) from Italy, Sweden, Denmark, the United Arab Republic, Argentina, and West Germany.

Sir Harrie Massey, President of the European Preparatory Commission on Space Research, also visited NASA.

Nationals from Japan, Norway, and Sweden participated in work-study programs at NASA installations during this time, and arrangements were made for nationals from Italy.

Nationals from the United Kingdom, Italy, China, India, Japan, West Germany, Switzerland, Pakistan, Turkey, Sweden, and Israel initiated or continued research at NASA facilities under the NASA postdoctoral research associateship program.

Arrangements were made for a number of outstanding astronomers and astrophysicists to visit NASA centers for discussions with the staffs in connection with the General Assembly of the International Astronomical Union. The major observatories and institutes of Australia, Belgium, Canada, France, Greece, the Netherlands, Japan, Switzerland, West Germany, and the United Kingdom are represented by this group of special visitors.

Special groups of scientific-technical personnel from Canada and the United Kingdom were accredited for intermittent visits to NASA facilities in connection with cooperative programs.

Seven Canadians, who will be among those to operate the NASA Minitrack station under construction at St. John's, Newfoundland, began training in October 1960 at NASA's Fort Myers, Fla., Minitrack station. NASA also conducted on-the-job training courses for foreign nationals at Minitrack stations in Antofagasta and Santiago. Chile; Quito, Ecuador; and Lima, Peru.

International Fellowships Program

Arrangements were begun for a new NASA international fellowships program. Under its provisions, foreign graduate students from a number of countries would take part in study and research programs at U.S. universities, on a shared-cost basis. Pilot programs are being arranged at the University of Chicago, the State University of Iowa, the University of Minnesota, the University of Wisconsin, Columbia University, and the University of Colorado.

The full program, which involves major U.S. universities offering the space sciences in their curriculums, will be able to accommodate about 100 students, and is scheduled to start in 1962.

Technical Discussions and Scientific Conferences

A total of 375 NASA scientists and U.S. officials participated in technical discussions and scientific conferences abroad, and in managing NASA overseas operations. In addition, NASA personnel participated in the International Committee on Space Research (COSPAR) in Florence, Italy, in April 1961.

Technical Information

In March 1961, NASA distributed Technical Report R–97, "Considerations Affecting Satellite and Space Probe Research With Emphasis on the Scout as Launch Vehicle." The report, which describes the facilities, supporting services, and organization needed for scientific space programs employing the Scout launch vehicle, is intended "as a guide and aid for scientists and engineers of all countries who are interested in space research" in cooperation with NASA.

In October 1960, NASA distributed—through COSPAR—a description of the Explorer VIII satellite experiment (launched November 3, 1960) to foreign scientists interested in ionospheric research.

Educational Materials Program

A pamphlet and a 15-minute color film, explaining Project Mercury in lay terms for those countries in which Project Mercury ground stations are located, were prepared and distributed. Besides versions in English, Spanish, Hausa, and Swahili, translations into other languages were planned.

Cooperative Projects

TIROS II Weather Satellite

Weather services of 18 nations responded to joint invitations from NASA and the U.S. Weather Bureau to participate in observations concurrent with those of the TIROS II experimental meteorological satellite launched on November 23, 1960. NASA provided orbital information to the foreign weather services so that they could conduct ground-based weather observations synchronized with satellite passes. The program was curtailed because of technical difficulties with the satellite. (See ch. 3.) A similar program is planned for future weather satellites.

Communications Satellites

In March 1961, Great Britain and France each entered a cooperative program with NASA for transatlantic testing of experimental communications satellites. Each Government plans to build a ground station on its own territory, at its own expense, for transmitting and receiving transatlantic telegraph, telephone, and television signals, as well as other types of transmissions relayed by NASA satellites.

The stations will be employed in NASA's Project Relay, a low-altitude active repeater satellite scheduled for 1962, and Project Rebound, multiple rigidized passive reflector satellites somewhat similar to Echo, which are set for 1963.

Other nations have also indicated an interest in participating in this program, and discussions are underway.

Argentina

A memorandum of understanding between NASA and the Argentine Space Commission was signed in June 1961, providing for future cooperation and familiarization in space research—specifically, by using small sounding rockets to extend Argentine research programs in meteorology, cosmic-ray detection, and ionospheric physics.

Australia

Arrangements were made to conduct a sounding rocket survey of ultraviolet radiation in the Southern Hemisphere skies in the fall of 1961. This will be a joint program of NASA and the Australian Ministry of Supply. NASA has arranged with the United Kingdom for the purchase of four British-made Skylark rockets for the program. The rockets will be launched at Woomera, Australia.

Canada

In June 1961, components of the "topside sounder" satellite (designed, instrumented, fabricated, and financed by the Canadian Defence Research Board) were tested in sounding rockets at Wallops Station, Va.

The satellite is scheduled for launch in 1962 by a U.S. Thor-Agena B vehicle; it will complement NASA satellite and sounding rocket studies of the ionosphere.

France

NASA and the French Committee on Space Research signed a memorandum of understanding in March 1961 contemplating space science cooperation along the following lines: The French plan to prepare proposals for very-low-frequency, aurora, airglow, and biological experiments. These will be prepared as appropriate for preliminary sounding rocket tests in the United States, and subsequent satellite launchings, possibly in 1963 or 1964.

NASA will assist France in planning a scientific sounding rocket facility on the south coast of Brittany. French scientists will be trained at NASA installations.

Italy

In January 1961, and again in April, the Italian Space Committee, in a cooperative program with NASA, launched scientific sounding rockets from Sardinia for studying winds in the upper atmosphere. The Nike-Cajun rockets climbed to about 100 miles, emitting sodium-vapor clouds which were studied optically. The April firings were coordinated with similar firings by NASA from Wallops Station, Va. (See chap. 4.)

Norway

NASA is cooperating with the Norwegian Space Committee in setting up a sounding rocket program directed at ionospheric research by (1) supporting Norway in the procurement of Nike rockets, (2) providing an appropriate sounding rocket launcher, and (3) providing technical assistance during the launchings.

Sweden

NASA will supply Arcas sounding rockets, and the Swedish Committee on Space Research will supply payloads for a cooperative program of scientific studies of noctilucent clouds in the upper atmosphere.

United Kingdom

During the report period, the United Kingdom and the United States carried forward a cooperative scientific program, thus far involving two earth satellites to be instrumented by the United Kingdom and launched by NASA.

The first, scheduled for 1962, will be a sphere, 2 feet in diameter, with four solar-cell paddles to generate power from sunlight. It will contain instruments to collect data on electron density, ion mass, and cosmic rays.

In March 1961, NASA and the United Kingdom agreed on the following experiments for the second United Kingdom satellite, scheduled for launch in 1963: (1) Galactic noise (natural radio signals emitted by the stars); (2) ozone in the atmosphere; and (3) micrometeoroid measurements.

The International Conference on Peaceful Uses of Outer Space

U.N. Decision Still Pending

A decision by the United Nations on a date and site for an International Conference on the Peaceful Uses of Outer Space is still pending. In the meantime, personnel in NASA's Office for the United Nations Conference (OUNC)[1] made preliminary plans.

[1] After the report period ended, the OUNC was closed, and its missions were assumed by the Office of International Programs and the Office of Technical Information and Education. The Office of International Programs is responsible for NASA interest in the Conference, and for liaison with other Government agencies.

Organizational Development

Organizational Changes in Field

Space Task Group

As a result of rapidly increasing activity in manned space flight, the Space Task Group (STG), Hampton, Va., was established on January 3, 1961, as a separate field installation reporting directly to the Office of Space Flight Programs in NASA Headquarters, Washington, D.C. Previously, STG had been an organizational unit of the Goddard Space Flight Center, Greenbelt, Md.

STG develops design criteria for manned space-vehicle systems, supervises manned space-flight operations, and interprets and reports the results of these flights. It manages the Mercury and Apollo manned space-flight programs.

Life Sciences Research Laboratory

On February, 1961, NASA established a Life Sciences Research Laboratory at Ames Research Center, Mountain View, Calif. The Laboratory will provide leadership and coordination of life sciences research conducted for NASA by other Government agencies and by industry and universities. It will engage in research on biological and medical aspects of space flight, and on possible extraterrestrial life.

Test Support Office

The NASA Test Support Office, Pacific Missile Range (PMR), was established in November 1960, at Point Mugu, Calif. An organizational element of the Launch Operations Directorate, Cape Canaveral, Fla., the Test Support Office will coordinate all NASA operations at PMR and provide necessary support. The Chief of the Office also serves on the staff of the Commander, PMR.

Goddard Space Flight Center Dedicated

NASA's Goddard Space Flight Center was dedicated on March 16, 1961, the 35th anniversary of the world's first flight of a liquid-propelled rocket developed and launched by the father of American rocketry, Dr. Robert F. Goddard. Detlev W. Bronk, President of the National Academy of Sciences, gave the dedication address. Mrs. Esther Goddard unveiled a bust of her late husband and received a special gold medal authorized by Congress. The medal was presented by Senator Robert S. Kerr, chairman of the Senate Committee on Aeronautical and Space Sciences, and Representative Overton Brooks, chairman of the House Committee on Science and Astronautics.

Institute for Space Studies Started by Goddard

In January 1961, the Goddard Space Flight Center established an Institute for Space Studies in New York City to conduct theoretical research pertaining to the space sciences. Major research areas include the internal structure of the earth, the moon, and other planetary bodies in the solar system; the atmospheres of the earth and planets; the interplanetary plasma; sun-earth relationships; the origin and evolution of the solar system; astrophysics; and celestial mechanics.

NASA Headquarters, the Dolly Madison House (June 30, 1961)

The programs of the Institute, while directly related to the experimental activities at the Goddard Space Flight Center, will also be concerned with the broader aspects of space science. The Institute will work in close collaboration with faculties of universities in the New York City area, and will supplement its 50-member staff by employing scientists from the universities and from nearby technical organizations as part-time consultants.

Organizational Changes in NASA Headquarters

Office of Programs Established

The Office of Programs was established on June 1, 1961, as a staff office reporting directly to the Associate Administrator. Its purpose is to pull together and evaluate information on the various technical programs in order to aid progress toward established goals. The Office of Programs is also responsible for budgeting and programing the resources available to NASA. There is an Assistant Director for each of four functional areas: Project Review, Resource Programing, Management Reports, and Facilities. The functions and staff of the Office of Program Analysis and Control and the Office of Reliability and Systems Analysis were absorbed into the new organization.

Office of Business Administration Redesignated

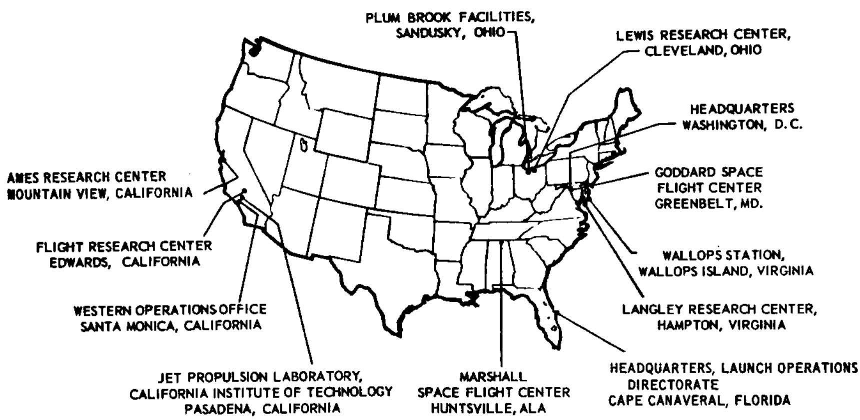
The Office of Business Administration was redesignated the Office of Administration on June 1, 1961. It continues to perform its previous administrative and management functions. A Headquarters Procurement Branch has been set up within the Procurement and Supply Division to carry out the research and development procurement previously handled for NASA Headquarters by the Goddard Space Flight Center.

Reassignment of Western Operations Office

Effective June 1, 1961, responsibility for exercising general direction of the Western Operations Office, Santa Monica, Calif., was transferred to the Office of Administration from the Associate Administrator. This change recognized the close relationships between the functions, particularly procurement, assigned the Western Operations Office and those of the Office of Administration and reduced the number of organizations reporting directly to the Associate Administrator.

Office of Space Flight Programs Reorganized

The size, scope, and national importance of manned space flight has led to the establishment of an Assistant Director for Manned Space Flight Programs in the Office of Space Flight Programs. The position of Assistant Director of Applications and Manned Flight has been abolished. Responsibility for communications and meteorology programs was transferred to the Assistant Director for Satellites and Sounding Rockets; responsibility for advanced technology to a newly established Assistant Director for Advanced Technology Programs. The significance of advanced technical development activities has increased continually as the space program has expanded. The new Assistant Director, unencumbered by other organizational responsibilities, will provide a focal point for these activities and will assure development of a positive and complete program in this area.



Locations of NASA installations, June 30, 1961

Organization Chart

The attached chart illustrates NASA organizational structure as of June 1, 1961. The functions of organizational units previously established are set forth in earlier semiannual reports to Congress.

Procurement, Contracts, and Grants

Bulk of NASA Funds Goes to Industry

About 80 cents of every NASA dollar goes for contracts with industry and other private organizations. During the report period, NASA obligated approximately $588 million to fund 74,748 procurement actions by NASA Headquarters and its eight field procurement offices.

Contract Awards

Approximately $336 million (57 percent) of the funds obligated represented purchases and contracts placed directly with private industry. About $18 million (3 percent) represented contracts and research grants awarded to nonprofit institutions or organizations; $85 million (15 percent) were obligated under contract with the California Institute of Technology for operation of the Jet Propulsion Laboratory; and $149 million (25 percent) were placed with or through other Government agencies.

Methods of Awarding Contracts.—Approximately $31 million (9 percent) of the direct awards to business were placed through formal advertising for competitive bids. About $177 million (53 percent) were placed through competitive negotiation; that is, proposals or quotations were solicited from more than one source and the awards were based on price, design, or technical consideration. Thus, $208 million (62 percent) of direct awards were placed through competitive procedures.

Small Business Shares NASA Awards.—NASA awarded approximately $52 million in purchases and contracts, or about 15 percent of the total direct awards to private industry, to small business firms. The awards were made through 45,675 procurement actions, 69 percent of the total placed with business.

Approximately $4 million, representing 276 actions, of the awards resulted from small business set-asides, that is, contracts that were designated in advance for small business.

The above figures include only prime contracts. In addition, large NASA prime contractors subcontract with small business firms for raw materials, component parts, and services.

Other Government Agencies Assist NASA Procurement

During the report period about $149 million (25 percent of NASA's procurement) were placed with or through other Government agencies, primarily the Department of Defense. Such purchasing accords with NASA's policy to avoid duplication of effort and to use existing resources most effectively and economically. NASA procures through the Defense Department items which the military departments, because of their own programs, can obtain from industry most economically. For example, NASA is procuring Agena B rockets through the Air Force, and has transferred funds to the Army for design, engineering services, installation, and checkout of a Saturn test facility at Marshall Space Flight Center, Huntsville, Ala. On the other hand, NASA is responsible for procuring Centaur for both NASA and Air Force programs.

Research and Development Procurement

Most of NASA's procurement is funded from its Research and Development appropriation. During this period, such procurement amounted to $507 million, or 86 percent of the total. Procurement funded from the Construction and Equipment Appropriation amounted to $71 million (12 percent). About $10 million (2 percent) were funded from the Salaries and Expenses Appropriation.

Major Contract Awards

Following are some of the major research and development contracts awarded by NASA in this report period:

(1) North American Aviation, Inc., Canoga Park, Calif., to design, develop, and construct H–1 rocket engine for the Saturn program. Estimated cost: $32 million.

(2) Grumman Aircraft Engineering Co., Bethpage, N.Y., to design, develop, and construct an orbiting astronomical observatory. Estimated cost: $32 million.

(3) Space Technology Laboratories, Inc., Los Angeles, Calif., to design, develop, and construct an orbiting geophysical observatory. Estimated cost: $25 million.

(4) Chance Vought Aircraft, Inc., Dallas, Tex., to design, develop, and construct five Scout research vehicles. Estimated cost: $6 million.

(5) General Electric Co., Philadelphia, Pa., to design and develop stabilization and control subsystem for Nimbus meteorological satellite. Estimated cost: $2.7 million.

Procurement Management

NASA-DOD Cooperative Procurement Arrangement

NASA and the Department of Defense jointly developed policies and procedures to facilitate the procurement of supplies or services by NASA from or through the military departments. These policies and procedures are included in both NASA Procurement Regulations and the Armed Services Procurement Regulations (ASPR).

NASA Negotiates Basic Agreements

A basic agreement is a written understanding between NASA and a contractor setting forth negotiated contract clauses applicable to future procurements during the term of the agreement. The basic agreement is used in conjunction with a formal contract specifying the requirements (such as scope of work, price, delivery, etc.) of a particular procurement. The contract incorporates or refers to the required or applicable clauses in the basic agreement.

NASA entered a basic agreement with North American Aviation, Inc., in February 1961, and started negotiating others with Canadian Commercial Corp., General Electric Co., Convair Division of General Dynamics Corp., Space Technology Laboratories, Inc., and Radio Corp. of America.

Procurement Regulations Issued

During the report period, NASA issued regulations on small business; price negotiation policies and techniques; review and approval of contractors' "make-or-buy" programs; procurement through the military departments; contract clauses and forms; patents, data, and copyrights; Federal, state, and local taxes; Government property; inspection and acceptance; procurement forms; numbering and distribution of contracts and grants; and integration of the reliability program with the procurement of major systems. Regulations are being drafted on terminations, responsible prospective contractors, handling of equal or identical bids, and utilities services.

Small Business

NASA Helps Small Business Obtain Subcontracts

NASA took a number of steps to assist small business concerns to obtain subcontracts. All proposed unclassified NASA research and development procurements which may result in contract awards of $100,000 or more are listed in the "Synopsis of U.S. Government Proposed Procurement, Sales, and Contract Awards," a daily publication of the Department of Commerce. The Synopsis summarizes requests for proposals and lists the names and addresses of firms invited by NASA to submit proposals. Firms interested in subcontracting can thus get in touch with potential prime contractors directly during the early stages of procurement.

In addition, NASA public information offices furnish, upon request, the names of companies that attend pre-proposal briefing conferences, and, after the closing date for receipt of proposals, the names of firms which submitted proposals.

NASA Procurement Regulations also require contractors holding contracts of $1 million or more to conduct a small business program. The Regulations specify what the contractor must do to increase subcontracting with small business concerns and require him to report the amount of such subcontracting to NASA. NASA periodically reviews the reports to determine the effectiveness of contractors' small business subcontracting programs.

Preliminary reports from 12 major prime contractors indicate that about 20 percent of their awards from NASA are subcontracted to small business firms.

Supply Management

Stores Management Manual Adopted

The NASA Stores Management Manual, setting forth policies for stores operations, was prepared and put into effect during the report period. The Manual's objectives: to achieve an optimum inventory level by applying improved management techniques; to minimize the cost of operating stores programs at field installations; and to establish a standard for evaluating the efficiency and effectiveness of NASA stores operations. Significant provisions are summarized below:

(1) *EOQ* (*Economic Order Quantity*)—a system for determining replenishment order quantities, with the aim of arriving at the lowest total cost of procuring and carrying a stores stock item.

(2) *High-sales, low-sales inventory control*—a system whereby stores items are accorded management effort in relation to their value.

(3) *Uniform commodity grouping*—uniform grouping of stores items for inventory and financial control.

(4) *Uniform stock numbering*—classification of stores items in accordance with the Federal Cataloging Program.

(5) *Management Reports*—a series of reports to assist management to control inventory levels and evaluate the efficiency and effectiveness of stores operations.

Research Grants and Contracts

Office is Contact Point

The Office of Research Grants and Contracts is a central point of contact for research laboratories of other Government agencies, educational institutions, and industrial and nonprofit organizations seeking to participate in the NASA research programs. Interested parties in any of the above categories submit unsolicited proposals to this office, which ensures evaluation of the proposals; awards grants and contracts; and, with NASA technical groups, administers the sponsored research.

Between October 1, 1960, and June 30, 1961, 1,106 proposals were received by this office, and 175 research awards, totaling $16,021,000, were made. One hundred twenty-six of these awards, totaling $12,794,340, were made to educational or nonprofit research institutions.

The awards are described and listed by state in Appendix I.

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Financial Management

Financial Management Has Wide Impact

During the report period NASA financial management activity included the following: Preparation, review, and internal approval of NASA appropriation estimates for fiscal year 1962; initiation of estimates for fiscal year 1963; and administration of funds appropriated by the Congress for fiscal year 1961. Financial management also installed an agencywide coding structure to establish uniform classification and identification of program effort throughout NASA for purposes of planning, programing, budgeting, accounting, and reporting.

The financial management organization also continued the development and refinement of accounting and reporting systems tailored to the needs of fast-moving programs. Of particular significance is a contractor finance reporting system which will provide, by major subdivisions of contract effort, information on costs to date and projected costs to completion.

The following tables depict the planned program level for fiscal year 1962 and the financial operations of the Agency during 1961.

Fiscal Year 1962 Program

Table 3 shows the planned level of effort in the "Salaries and expenses" and "Construction of facilities" appropriations and in each program area under the "Research and development" appropriation. These amounts are subject to reprograming during the year to meet new or modified responsibilities and requirements.

TABLE 3.—*NASA budget estimates, fiscal year 1962*

[In thousands]

Appropriations		*1962 estimate*
Salaries and expenses		$226, 686
Research and development:		
Support of NASA plant	$89, 110	
Research grants and contracts	7, 600	
Life sciences	20, 620	
Sounding rockets	9, 000	
Scientific satellites	72, 700	
Lunar and planetary exploration	159, 899	
Meteorological satellites	50, 200	
Communications satellites	94, 600	
Mercury	74, 245	
Apollo	160, 000	
Launch-vehicle technology	27, 000	
Launch-operations development	1, 500	
Spacecraft technology	10, 360	
Solid propulsion	3, 100	
Liquid propulsion	93, 020	
Electric propulsion	6, 800	
Nuclear-systems technology	36, 000	
Space-power technology	5, 500	
Scout	3, 675	
Delta	2, 900	
Centaur	56, 400	
Saturn	224, 160	
Tracking and data acquisition	38, 650	
Nova	48, 500	
Total, research and development		1, 295, 539
Construction of facilities		262, 075
Total		1,784, 300

Financial Report, June 30, 1961

The following sets forth the total amounts of funds obligated and expended during fiscal year 1961, together with actions pending at the end of the fiscal year.

TABLE 4.—*NASA fiscal year 1961 program effort*

[In thousands]

Appropriations	*Total obligations*	*Total expenditures*	*Pending commitments*
Salaries and expenses	$172, 222	-------	$159, 142
Research and development:			
Support of NASA plant	56, 173	$ 5, 635	41, 009
Support of JPL research	7, 821	-------	6, 820
Grants and contracts	5, 335	728	4, 390
Sounding rockets	7, 781	3, 558	7, 023
Scientific satellites	37, 282	3, 758	26, 970
Lunar and planetary exploration	63, 722	1, 184	65, 051
Meteorology	13, 472	1, 943	6, 890
Communications	10, 763	2, 764	2, 557
Manned space flight	71, 345	17, 224	76, 948
Tracking and data acquisition	23, 712	2, 430	19, 106
Launch operations development	498	100	88
Vehicle systems technology	7, 999	418	3, 494
Solid rockets	2, 209	334	1, 478
Liquid rockets	59, 122	1, 638	45, 050
Nuclear systems technology	10, 121	4, 146	7, 111
Electric propulsion	3, 647	440	1, 443
Space power technology	4, 874	558	2, 700
Spacecraft technology	1, 451	-------	1, 228
Scout	8, 070	477	7, 789
Delta	8, 049	141	12, 627
Centaur	62, 761	92	49, 996
Saturn	114, 539	393	76, 116
Vehicle procurement	53, 915	2, 223	16, 098
Propellant procurement	6, 375	162	3, 910
Life sciences	3, 983	848	1, 112
Total, research and development	645, 019	51, 194	487, 004
Construction and equipment	98, 226	-------	98, 162

Personnel

The NASA Staff

During the report period, the roster of NASA staff members increased by 1,868. Table 5 indicates the distribution of personnel among NASA's organizational units at the beginning and end of the period.

NASA's total work force of 16,995 persons on June 30, 1961, was divided into the following categories:

... Scientists and engineers in aerospace technology and in related supervisory and management positions: 5,455.

... Engineers, mathematicians, and other technical professionals supporting the above group: 310.

... Scientific and engineering assistants and technicians such as draftsmen, designers, computer specialists, and illustrators: 2,295.

... Professional, administrative, and management positions in legal, procurement, personnel, finance, technical information, education, and related specialized areas: 943.

... Clerical and administrative positions: 2,635.

... Skilled trades and crafts employees, and related skilled, semi-skilled, and unskilled laborers paid at prevailing locality rates: 5,833.

Included in the NASA staff are 116 foreign scientists and 88 military personnel on loan from the armed services.

The staffing figures do not include 2,700 employees of the Jet Propulsion Laboratory, Pasadena, Calif., which is operated for NASA under contract by the California Institute of Technology.

TABLE 5.—*Distribution of NASA personnel*

Organizational unit	Sept. 30, 1960	June 30, 1961
Ames Research Center	1, 417	1, 462
Flight Research Center	411	447
Goddard Space Flight Center	1, 601	1 ,599
Langley Research Center	3, 209	3, 338
Lewis Research Center	2, 715	2, 773
Life Sciences Field Station	----	9
Marshall Space Flight Center	5, 230	5, 948
Space Task Group	----	794
Wallops Station	296	302
Western Operations Office	42	60
Total, field	14, 921	16, 732
Headquarters	626	735
AEC–NASA Nuclear Office	----	4
Total	15. 547	17. 471

Recruitment of Scientific Personnel

Expanding NASA programs increased the personnel requirements of the Agency. During the report period, NASA representatives sought employees at professional and technical society meetings, at industrial firms which were reducing their staffs, and in cities considered possible sources of trained manpower. NASA recruiters also interviewed graduating students at almost 200 colleges and universities throughout the country. Advertising in technical and professional journals was used in addition to recruiting visits. As a result, 984 scientists and engineers accepted employment with NASA.

Review of Work Reveals New Areas of Specialization

An extensive review of the work of NASA scientists and engineers revealed new areas of specialization. Subsequently, the patterns and content of their work were delineated and the required special skills were identified. The identification and description of these specializations have served to increase the efficiency of personnel management and aid in recruiting, placement, and training. In an aerospace technology examination announcement issued December 6, 1960, the U.S. Civil Service Commission recognized these new areas and requirements.

NASA Astronaut and Others Honored

On May 5, 1961, Alan B. Shepard, Jr., NASA astronaut, was awarded the NASA Distinguished Service Medal for outstanding contributions to the advancement of space technology and a demonstration of man's capabilities in suborbital space flight.

In June 1961, Edward R. Sharp, retired Director of Lewis Research Center, was awarded the NASA Medal for Outstanding Leadership in the planning, construction, and operation of unique research laboratories; in the training and development of men; and in the promotion of public interest in support of aeronautical and space science research.

On June 23, 1961, Dr. Henry J. E. Reid, retired former Director, Langley Research Center, Hampton, Va., was presented the NASA Medal for Outstanding Achievement for his role in development and direction of the Langley Research Center as an organization which attained worldwide recognition in scientific research in aeronautics and space; in the training and development of other recognized scientific leaders; and for his pioneering leadership in research on instruments and laboratory facilities for measurement of flight vehicle performance.

On January 18, 1961, the American Astronautical Society presented its Space Flight Award to Homer E. Newell, Deputy Director, Office of Space Flight Programs. The award was made for outstanding contributions to the field of space research.

In February 1961, John F. Parsons, Associate Director of Ames Research Center, and Abraham Hyatt, Director of Program Planning and Evaluation, were elected Fellows of the Institute of Aerospace Sciences. Fellowships are limited to 10 each year.

On March 16, William J. O'Sullivan, Jr., Langley Research Center, was presented the 1961 Astronautics Engineer Achievement Award of the National Rocket Club. The citation reads in part: "For his vision in conceiving the use of lightweight inflatable satellites for study of the characteristics of the upper atmosphere and outer space as well as their use as space relays for transcontinental and transoceanic communication." Mr. O'Sullivan is responsible for the concept and directed design and development of the Echo passive communications satellite.

On June 15, the Institute of Aerospace Sciences presented Joseph A. Walker, NASA's X–15 test pilot, the 1961 Octave Chanute Award "for experimental flight testing of and engineering contributions to high speed flight research programs, including the X–1 through the X–15."

On June 19, trustees of the Clifford B. Harmon Trust announced award of the 1961 Harmon International Aviator's Trophy for outstanding and extraordinary feats of individual piloting skill during 1960 to Joseph A. Walker, A. Scott Crossfield of North American Aviation, and Air Force Maj. Robert A. White. The pilots were cited for outstanding accomplishments in flying the rocket-powered X–15 research airplane.

Wolfgang E. Moeckel, Chief, Electromagnetic Propulsion Division, Lewis Research Center, and Dr. Joseph W. Siry, Chief, Theory and Analysis Staff, Tracking and Data Systems, Goddard Space Flight Center, were presented Arthur S. Flemming Awards on February 16, 1961. These awards, sponsored by the Junior Chamber of Commerce of Washington, D.C., honor outstanding men under 40 in the Federal Government.

Executive Personnel Changes

On February 14, James E. Webb was sworn in as NASA Administrator. Mr. Webb had previously served the Government as Under Secretary of State and as Director of the Bureau of the Budget under President Truman. T. Keith Glennan, former NASA Administrator, had resigned effective January 20. Hugh L. Dryden, NASA Deputy Administrator, served as Acting Administrator in the interim. Mr. Webb's selection was announced by the President on January 30. His nomination was sent to the Senate on February 8, and was confirmed the following day.

Paul G. Dembling was appointed Acting Assistant Administrator for Congressional Relations, NASA Headquarters, on March 7, 1961. He was formerly Assistant General Counsel.

Harold B. Finger was appointed Assistant Director for Nuclear Applications, Office of Launch Vehicle Programs, NASA Headquarters, on March 5, 1961. He is Manager of the joint AEC–NASA Space Nuclear Propulsion Office.

William A. Fleming was appointed Assistant Director for Project Review, Office of Programs, NASA Headquarters, on June 1, 1961. He was formerly technical assistant to the Director of Space Flight Programs.

Abraham Hyatt was appointed Director of Program Planning and Evaluation, NASA Headquarters, on November 30, 1961. He was formerly Deputy Director of Launch Vehicle Programs.

Oakley B. Lloyd, Jr., was appointed Director of Public Information, NASA Headquarters, on February 7, 1961. His former position was staff assistant, U.S. Senate.

Robert G. Nunn, Jr., was appointed special assistant to the Administrator, NASA Headquarters, on May 4, 1961. He was formerly Assistant General Counsel.

DeMarquis D. Wyatt was appointed Director, Office of Programs, Office of the Associate Administrator, NASA Headquarters, on June 1, 1961. He was formerly Assistant Director for Program Planning and Coordination in the Office of Space Flight Programs.

CHAPTER 20

Other Activities

Scope of Chapter

This chapter reports significant developments in (1) contributions, (2) technical information and education, and (3) interagency cooperation.

Contributions

Purpose and Authority

The NASA Inventions and Contributions Board (see app. D for membership), under authority of, and in accordance with, Section 305(f) and Section 306 of the National Aeronautics and Space Act of 1958, evaluates for monetary awards scientific and technical contributions—whether patentable or unpatentable—received from *any person*, as the term "person" is defined in the Act. Oral hearings are granted by the Board, on request, to applicants for awards.

Contributions Awards

During the report period, 2,327 communications were received by the Board and 1,408 scientific and technical contributions were evaluated.

On January 17, NASA presented the first contribution award—$3,000 to Frank T. McClure for his invention of the Satellite Doppler Navigation System, which is the basis of the Navy's Transit navigation satellite program. Dr. McClure is Chairman of the Research Center of Johns Hopkins University's Applied Physics Laboratory.

Awards to NASA Inventors

An administrative regulation of July 6, 1960, authorized the Inventions and Contributions Board to consider all inventions of NASA employees for which patent applications were to be filed. Inventions not meriting awards under the National Aeronautics and Space Act were to be considered for award under the Government Employees Incentive Awards Act of 1954.

A second administrative regulation on June 27, 1961, authorizes the Board to make cash awards up to and including $5,000 to NASA inventors under a NASA Incentive Awards Program. The regulation also provides that a minimum of $50 be awarded for each employee invention on which a patent application is to be filed.

Technical Information and Education

NASA's technical information and educational programs are designed to contribute substantially toward fulfilling the provision of the National Aeronautics and Space Act requiring that: "The Administration . . . shall . . . provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof." The Office of Technical Information and Educational Programs made available to scientists, engineers, educators, students, and the public at large information on NASA's scientific activities, and disseminated, both within the agency and externally, technical data, including translations of foreign technical papers.

Technical Information

More Effective Documentation System.—To provide a basis for improved bibliographic control and distribution of the enormous quantity of data produced for the NASA technical programs, the agency studied its technical information program and other information services available to the aeronautics and space-science community. One result was an invitation to prospective contractors with special competence in data processing to submit proposals to develop a NASA technical documentation facility. Copies of the request for proposal were obtained by more than 80 organizations interested either in submitting proposals or in studying the scope of the program. Deadline for submission of proposals is July 5, 1961.

The proposal requirements called for the contractor to:

. . . Acquire and select, in accordance with detailed NASA guides, documentary material for NASA library collections; abstract and index the items of value; compile indexed abstract journals to announce the newly acquired materials, and prepare the journals for printing and distribution by NASA.

. . . Process selected acquisitions into microform for economical duplication and full-size reproduction; place copies of processed documents in the NASA library system.

. . . Maintain comprehensive bibliographic records of the acquired material and provide responsive answers to reference questions from NASA, its contractors, and other participants in the national space program; prepare for distribution of up-to-date bibliographies in several preselected specialized subject areas.

. . . Install and operate automated and mechanized equipment to provide management and bibliographic control of scientific and technical documents.

Foreign Scientific Information.—NASA has established a clearinghouse for handling translations relevant to its technical programs, to (1) preclude duplication of translating, (2) coordinate translation work with other organization, and (3) provide immediate access to translations of foreign technical information. The activity is receiving assistance from other Government agencies and private translation services. Monthly lists of completed and planned translations are compiled for distribution to NASA centers, contractors, and cooperating organizations.

Translations include technical books and articles of special interest. The English translation is distributed as a NASA Technical Translation and placed on public sale through the Office of Technical Services, Department of Commerce. During the report period, NASA published 25 Technical Translations.

Dissemination of Technical Information.—Technical information generated within NASA was released to the scientific community through Technical Reports and Technical Notes, proceedings of meetings and conferences, and papers published in professional journals.

During the report period NASA distributed 483 unclassified technical publications. Each of these publications was also placed on public sale either through the Government Printing Office or the Office of Technical Services, Department of Commerce. In addition, 150 classified technical reports went to selected Government and other organizations participating in U.S. aeronautic and space activities.

Results of NASA-sponsored research and development were also discussed in more than 450 papers and articles presented at technical meetings or published in scientific journals. Among the proceedings published by NASA was a report on the May 5, 1961, Project Mercury test, entitled: "Conference on Medical Results of the First U.S. Manned Suborbital Space Flight, A Compilation of Papers Presented, June 6, 1961."

Expansion of Exchange Program.—Initial steps were taken to broaden and improve NASA's exchange agreements with other domestic and foreign scientific activities, to acquire documentary materials not available through existing publication or distribution services.

Dictionary of Space Terms.—Basic definitions required for a review draft of a NASA "Dictionary of Space Terms" were formulated. Publication is scheduled for mid-1962.

Educational Services

Motion Pictures and Publications.—NASA's educational program activities include development and production of publications and motion pictures for nontechnical audiences and educational services for teachers and students.

Information disseminated in the educational services program explains not only the scientific aspects of space activity but also the social, economic, and political implications. Because of the lag between accomplishments in space science and technology and inclusion of information on these matters in textbooks and other educational media, NASA provides such information directly to teachers and students as an interim measure.

Wide Range of Educational Services Provided.—Typical of educational services undertaken were:

...Consultation service, upon request, to State departments of public instruction, colleges, universities, and other educational institutions on curriculum enrichment in space education.

...Assistance to college officials in aeronautical-space education workshops for teachers and school administrators. NASA participated in more than 143 college and university workshops during the summer of 1961 and provided materials for others.

...Development, through a contract with Science Service, Inc., Washington, D.C., of a paperback book on the Nation's space program for the high school science student. First distribution is to be made to supervisors of approximately 28,000 science clubs in high schools throughout the country.

...Initiation of development, jointly with the National Science Teachers Association, of a series of paperback books on space science education. The first volume, to be issued November 1961, is entitled, "Spacecraft." Principal distribution will be to leaders of "Future Scientists of America Clubs" and to high school science teachers.

...Development, through a contract with Franklin Institute, Philadelphia, Pa., of a pilot version of a traveling space science demonstration unit (called "Spacemobile") to be used in high schools and colleges throughout the country. Drawing upon experience with the pilot unit, NASA procured three additional, improved versions. A typical "Spacemobile" demonstration illustrates the basic principles of rocketry and the launching and orbiting of satellites and deep space probes. Graphic portrayals employ models of such experiments as TIROS, Echo, Pioneer V, Mercury, and Saturn. Three

Spacemobiles were available for teachers' summer workshops; their use extended to many states (including Alaska), as well as to Puerto Rico and the Virgin Islands.

...Arrangement for NASA participation in the National Science Fair awards program for students. NASA awarded certificates to two winners in each of three categories—space science, rockets, and manned space flight—and was host to the winners and their teacher-sponsors at NASA facilities most closely related to their science projects.

...Initiation of research of educational space materials for eventual use in grade and high school courses.

...Employment of the National Aviation Education Council to develop bibliographies of selected space-science and related books, pamphlets, and teaching aids at the elementary, secondary, and college levels. Bibliographies for the elementary and secondary grades were completed and distributed.

...Provision of NASA scientists and technologists, and demonstrations, including films, models, and other materials, to educational TV programs at State and local levels.

...Development of documentary and report motion pictures and preparation for production of comprehensive film footage on NASA activities for use in educational films and TV programs.

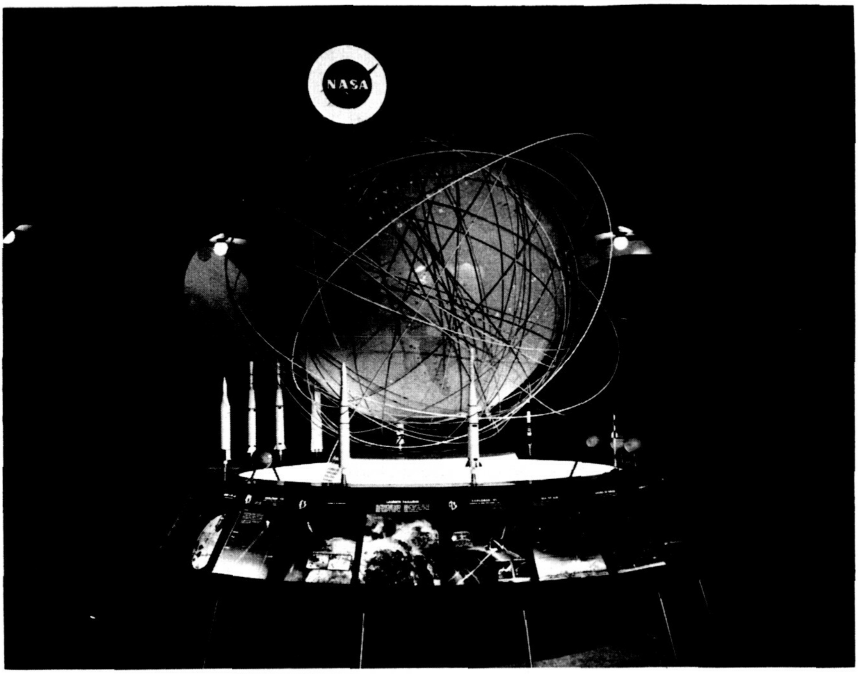
Exhibits

Exhibits activities and resources both increased during the report period. Exhibits were developed ranging in size from tabletop units suitable for school-library display to comprehensive presentations, with full-scale models, requiring as much as 3,000 square feet of display space.

To meet the growing public demand for showings of replicas of the Project Mercury capsule, 12 new exhibits were constructed. These include a full-scale model of the capsule, containing a manikin astronaut, complete with space suit, helmet and boots.

The "Freedom Seven" Mercury capsule in which astronaut Alan B. Shepard, Jr., made the first U.S. suborbital rocket flight was being prepared for display in the Smithsonian Institution as the report period ended.

A NASA exhibit, consisting of an 8-foot-diameter world globe encircled by varicolored curved tubing representing orbits of manmade satellites, was displayed in the Chicago Museum of Science and Industry, the Case Institute of Technology (Cleveland, Ohio), the Rotunda of the Old Office Building of the House of Representatives, and at the First National Conference on the Peaceful Uses of Outer Space, held at Tulsa, Okla.



NASA's World Globe exhibit in the rotunda of the Old House Office Building

Historical Program

The NASA historical program involves the following concurrent activities: Identification and collection of program documents basic to historical recordkeeping; collation and organization of this information; and production of historical monographs, reports, and analyses.

During the period, NASA issued "Aeronautics and Astronautics: An American Chronology of Science and Technology in the Exploration of Space, 1915–1960." The hard-cover volume may be purchased from the Government Printing Office at $1.75 per copy.

The Historical Office of Marshall Space Flight Center prepared the first *Semiannual History of MSFC* and several specialized chronologies.

Reports

During the period, NASA issued its "Fourth Semiannual Report to Congress—April 1, 1960, through September 30, 1960" and, with the cooperation of other Government agencies, "Report to Congress from the President of the United States, U.S. Aeronautics and Space Activities, January 1 to December 31, 1960." In addition, classified quarterly reports on NASA progress in aeronautics and space technology were submitted to the President.

Interagency Cooperation and Coordination

NASA programs—because they draw together the traditional areas of scientific study and influence political, social, commercial, and other aspects of national and world affairs—are interrelated with the programs of numerous other Government agencies. Accordingly, coordination and cooperation between NASA and such agencies are required for the most productive employment of Government resources. Typical of cooperative endeavors during the report period are the following:

National Launch Vehicle Program

On February 23, 1961, the NASA Administrator and Roswell L. Gilpatric, Deputy Secretary of Defense, endorsed an agreement that "neither DOD nor NASA will initiate development of a launch vehicle or booster for space without the written acknowledgment of the other agency that such a new development would be deemed consistent with the proper objectives of the National Launch Vehicle Program."

In another cooperative measure, NASA and the Department of Defense agreed that a single agency should be responsible for development and procurement of each major launch vehicle, without regard to its intended military or civilian use. Other cooperative measures also resulted from studies and discussions of the NASA-DOD Aeronautics and Astronautics Coordinating Board. (See app. C for membership.)

Communications Satellites

On February 27, the NASA Deputy Administrator and Frederick W. Ford, Chairman of the Federal Communications Commission, signed a memorandum setting forth policy and delineating responsibilities in civil communications satellite programs. The agencies agreed that: (1) They would work together on space telecommunications, encouraging participation of private industry cooperating as appropriate with other Government agencies; (2) NASA would concentrate on advancement of technology while FCC would develop policy and license and regulate common carriers; and (3) both agencies would facilitate international cooperation, consistent with Department of State policies and within the framework of U.S. goals and obligations.

National Operational Meteorological Satellite System

In April 1961, an interagency Panel on Operational Meteorological Satellites recommended and described a plan for establishment of a National Operational Meteorological Satellite System. Data from the system would be used by all U.S. weather services and would be provided to weather services of other nations.

Agencies participating in the panel were Department of Defense, U.S. Weather Bureau, Federal Aviation Agency, and NASA. The panel operated under the auspices of the National Coordinating Committee for Aviation Meteorology.[1]

Overseas Exhibit of Freedom 7

NASA, the U.S. Information Agency, and the Department of State arranged for exhibit of the Freedom 7 Mercury capsule at two international fairs which drew a total of 1,800,000 visitors. One was the International Air Show, Paris, France, May 25–June 4, 1961; the other, the Electronic and Nuclear Fair, Rome, Italy, June 13–25, 1961. It was Freedom 7 in which astronaut Alan B. Shepard, Jr., made his memorable ballistic flight of May 5, 1961.

Nuclear Rocket Engine Development

As the period closed, NASA and the Atomic Energy Commission were reviewing an industrial-team study on architectural and engineering requirements of a Nuclear Rocket Engine Development Facility, preparatory to designing specific buildings, test stands, utilities, and other units. The joint AEC–NASA Space Nuclear Propulsion Office (SNPO), which manages the nuclear-rocket program, had directed the study.

In June 1961, SNPO announced plans to contract for initial work in development of NERVA (Nuclear Engine for Rocket Vehicle Application). The contractor's tasks will include preliminary design of, preparing detailed plans for, and certain research and development related to NERVA; and assisting the Los Alamos Scientific Laboratory in designing facilities and in connection with reactor tests.

Commercial Supersonic Transport Aircraft

On June 28, 1961, the NASA Administrator, the Federal Aviation Agency Administrator, and the Secretary of Defense signed a report

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[1] Funds for initial implementation of the National Operational Meteorological Satellite System were included in a supplemental appropriations bill signed by the President in Oct. 1961. This will be a joint NASA-U.S. Weather Bureau effort funded by the Weather Bureau.

of a joint study on development of a commercial supersonic transport aircraft. In the paper, the three agencies urged the United States to undertake a program leading to an operational supersonic transport "in the 1970 time period." [2]

The report concluded that development of a commercial supersonic transport aircraft is technically feasible, noting that substantial research and development is required to attain necessary safety, reliability, and economy. Such an aircraft was seen as indispensable to continued U.S. leadership in world commercial aviation. Important economic benefits were also envisaged through production of this aircraft.

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[2] An FAA appropriation bill including funds for supersonic transport research was approved subsequent to this period. Roles of the three agencies in this program are: FAA—"Leadership and fiscal support"; NASA—"Basic research and technical support"; and DOD (USAF); "Administrative and technical support."

Appendix A

MEMBERSHIPS OF CONGRESSIONAL COMMITTEES ON AERONAUTICS AND SPACE

(October 1, 1960–June 30, 1961)

Senate Committee on Aeronautical and Space Sciences

ROBERT S. KERR, Oklahoma, *Chairman*
RICHARD B. RUSSELL, Georgia
WARREN G. MAGNUSON, Washington
CLINTON P. ANDERSON, New Mexico
STUART SYMINGTON, Missouri
JOHN STENNIS, Mississippi
STEPHEN M. YOUNG, Ohio
THOMAS J. DODD, Connecticut
HOWARD W. CANNON, Nevada
SPESSARD L. HOLLAND, Florida

STYLES BRIDGES, New Hampshire
ALEXANDER WILEY, Wisconsin
MARGARET CHASE SMITH, Maine
CLIFFORD P. CASE, New Jersey
BOURKE HICKENLOOPER, Iowa

House Committee on Science and Astronautics

OVERTON BROOKS, Louisiana, *Chairman*
GEORGE P. MILLER, California
OLIN E. TEAGUE, Texas
VICTOR L. ANFUSO, New York
JOSEPH E. KARTH, Minnesota
KEN HECHLER, West Virginia
EMILIO Q. DADDARIO, Connecticut
WALTER H. MOELLER, Ohio
DAVID S. KING, Utah
J. EDWARD ROUSH, Indiana
THOMAS G. MORRIS, New Mexico
BOB CASEY, Texas
WILLIAM J. RANDALL, Missouri
JOHN W. DAVIS, Georgia
WILLIAM F. RYAN, New York
JAMES C. CORMAN, California
JOHN W. MCCORMACK, Massachusetts

JOSEPH W. MARTIN, JR., Massachusetts
JAMES G. FULTON, Pennsylvania
J. EDGAR CHENOWETH, Colorado
WILLIAM K. VAN PELT, Wisconsin
PERKINS BASS, New Hampshire
R. WALTER RIEHLMAN, New York
JESSICA MCC. WEIS, New York
CHARLES A. MOSHER, Ohio
RICHARD L. ROUDEBUSH, Indiana
ALPHONZO E. BELL, California

Appendix B

Membership of the
National Aeronautics and Space Council

(June 30, 1961)

Vice President LYNDON B. JOHNSON, *Chairman*

DEAN RUSK
Secretary of State

ROBERT S. McNAMARA
Secretary of Defense

GLENN T. SEABORG
Chairman, Atomic Energy Commission

JAMES E. WEBB
Administrator, National Aeronautics and Space Administration

Executive Secretary
EDWARD C. WELCH

Appendix C

Membership of the NASA–DOD Aeronautics and Astronautics Coordinating Board

(June 30, 1961)

Co-chairmen

Dr. HAROLD BROWN, Director of Defense Research and Engineering
Dr. HUGH L. DRYDEN, Deputy Administrator, NASA

Members at Large

Dr. ROBERT C. SEAMANS, JR., Associate Administrator, NASA

Mr. WILLIAM A. FLEMING, Assistant Director for Technical Programs, NASA (alternate to Dr. Seamans)

Army Member at Large (Vacant)—Mr. RICHARD S. MORSE resigned effective 1 June 1961

Lt. Gen. A. G. TRUDEAU, Chief of Research and Development, Department of the Army (alternate)

Manned Space Flight Panel

Board Member and Chairman: Dr. ABE SILVERSTEIN, Director of Space Flight Programs, NASA

Vice Chairman: Dr. JOSEPH V. CHARYK (*Acting*), Under Secretary of the Air Force

Unmanned Spacecraft Panel

Board Member and Chairman: Mr. MORTON J. STOLLER, Assistant Director for Satellite and Sounding Rocket Programs, NASA

Vice Chairman: Mr. JOHN H. RUBEL, Assistant Secretary of Defense and Deputy Director of Defense Research and Engineering

Launch Vehicles Panel

Board Member and Chairman: Dr. JOSEPH V. CHARYK (*Acting*), Under Secretary of the Air Force

Vice Chairman: Maj. Gen. DON R. OSTRANDER, USAF, Director of Launch Vehicles Programs, NASA

Space Flight Ground Environment Panel

Board Member and Chairman: Col. PAUL T. COOPER, USAF, Acting Assistant Director of Defense Research and Engineering (Ranges and Space Ground Support)

Vice Chairman: Dr. ABE SILVERSTEIN, Director of Space Flight Programs, NASA

Supporting Space Research and Technology Panel

Board Member and Chairman: Mr. IRA H. ABBOTT, Director of Advanced Research Programs, NASA

Vice Chairman: Mr. JOHN B. MACAULEY, Assistant to Director of Defense Research and Engineering

Aeronautics Panel

Board Member and Chairman: Vice Adm. JOHN T. HAYWARD, USN, Deputy Chief of Naval Operations (Development)

Vice Chairman: Mr. MILTON B. AMES, Deputy Director of Advanced Research Programs, NASA

Secretariat

Secretary for DOD: Mr. ALVIN G. WAGGONER (*Acting*)

Secretary for NASA: Mr. WILLIAM J. UNDERWOOD, Office of the Administrator, NASA

Appendix D

Membership of NASA Inventions and Contributions Board

(October 1, 1960–June 30, 1961)

Chairman

ROBERT E. LITTELL, Assistant for Facilities, Office of Advanced Research Programs

Vice Chairman

PAUL G. DEMBLING, Acting Assistant Administrator for Congressional Relations, Office of the Administrator

Members

ELLIOT MITCHELL, Assistant Director for Propulsion, Office of Launch Vehicle Programs

J. ALLEN CROCKER, Chief, Coordinator for Lunar and Planetary Programs, Office of Space Flight Programs

C. GUY FERGUSON, Assistant Classification and Organization Officer, Personnel Division, Office of Administration

Executive Secretary

JAMES A. HOOTMAN, NASA Inventions and Contributions Board

Appendix E

Membership of NASA Advisory Committee on Space Medical and Behavioral Sciences

(October 1, 1960–June 30, 1961)

ROBERT S. MORISON, M.D., *Chairman*, Director, Medical and Natural Sciences, the Rockefeller Foundation, 49 West 49th Street, New York 20, N.Y.

Dr. FRANK A. BEACH, Professor of Psychology, University of California, Berkeley 4, Calif.

WEBB E. HAYMAKER, M.D., Chief, Neuropathology Branch, Armed Forces Institute of Pathology, Washington 25, D.C.

ROBERT B. LIVINGSTON, M.D., Director, Basic Research, National Institute of Mental Health, National Institutes of Health, Bethesda 14, Md.

Dr. GEORGE A. MILLER, Department of Psychology, Harvard University, Cambridge 38, Mass.

Dr. NELLO PACE, Professor of Physiology, Department of Physiology, University of California, Berkeley 4, Calif.

STANLEY J. SARNOFF, M.D., Chief, Laboratory of Cardiovascular Physiology, National Heart Institute, National Institutes of Health, Bethesda 14, Md.

Dr. STEWART G. WOLF, JR., Professor and Head, Department of Medicine, the University of Oklahoma Medical Center, 800 Northeast 13th Street, Oklahoma City 4, Okla.

Col. CHARLES H. ROADMAN, MC, USAF—NASA
Secretary

Appendix F

Membership of NASA Advisory Committee on Space Biology

(October 1, 1960–June 30, 1961)

Dr. MELVIN CALVIN, *Chairman*, Professor of Chemistry, University of California, Berkeley 4, Calif.

Dr. NORMAN H. HOROWITZ, *Vice Chairman*, Professor of Biology, California Institute of Technology, Pasadena 4, Calif.

Dr. PHILIP ABELSON, Geophysical Laboratory, Carnegie Institution of Washington, 2801 Upton Street, Washington 8, D.C.

Dr. SIDNEY W. FOX, Oceanographic Institute, Florida State University, Tallahassee, Fla.

Dr. HENRY LINSCHITZ, Department of Chemistry, Brandeis University, Waltham, Mass.

Dr. C. S. PITTENDRIGH, Department of Biology, Princeton University, Post Office Box 704, Princeton, N.J.

Dr. CARL E. SAGAN, Department of Astronomy, University of California, Berkeley 4, Calif.

Dr. RICHARD S. YOUNG—NASA, *Secretary*

Appendix G

Membership of NASA Advisory Committe on Flight Medicine and Biology

(October 1, 1960–June 30, 1961)

W. RANDOLPH LOVELACE II, M.D., *Chairman*, the Lovelace Foundation, 4800 Gibson Boulevard SE., Albuquerque, N. Mex.

Mr. ADOLPH BIALECKI, Head, Chemical Engineering Section, Research and Development Department, Electric Boat Co., Groton, Conn.

Lt. Col. JOSEPH A. CONNER, JR., MC, USAF, Chairman, Aerospace Nuclear Safety Board, Division of Reactor Development, U.S. Atomic Energy Commission, Washington 25, D.C.

Mr. A. SCOTT CROSSFIELD, Chief Engineering Test Pilot, North American Aviation, Inc., International Airport, Los Angeles 45, Calif.

Brig. Gen. DON D. FLICKINGER, MC, USAF., Assistant for Bioastronautics, Headquarters, ARDC, Andrews Air Force Base, Md.

ROBERT GALAMBOS, M.D., Chief, Department of Neurophysiology, Walter Reed Army Institute of Research, Washington 12, D.C.

Capt. CLIFFORD P. PHOEBUS, MC, USN, Director of Astronautics, Bureau of Medicine and Surgery, Department of the Navy, Washington 25, D.C.

HENNIG VON GIERKE, Ph. D., Chief, Bioacoustics Branch, Biomedical Laboratory, Aerospace Medical Division, Wright Air Development Division, Wright-Patterson Air Force Base, Ohio.

Dr. ALEXANDER C. WILLIAMS, Senior Project Engineer, Engineering Project Management, Hughes Aircraft Co., Culver City, Calif.

G. DALE SMITH—NASA, *Secretary*

Appendix H

MEMBERSHIPS OF NASA SPACE SCIENCES STEERING COMMITTEE AND SUBCOMMITTEES AND OF RESEARCH ADVISORY COMMITTEES

(June 30, 1961)

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Executive Secretary: HENRY E. STAUSS

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EDGAR M. CORTRIGHT
FREEMAN H. QUIMBY
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MORTON J. STOLLER

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E. C. BUCKLEY (H. R. BROCKETT)[2]
MILTON ROSEN (E. W. HALL)
N. D. SANDERS (MORRIS TEPPER)

[1] Committee and subcommittee members are on the NASA staff.
[2] The second individual is an alternate.

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Secretary: M. J. AUCREMANNE

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Dr. A. KEITH PIERCE
Dr. BENGT STROMGREN
Dr. RICHARD TOUSEY

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G. J. JACOBS
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[1] Committee and subcommittee members are on the NASA staff.

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Mr. ROBERT T. JONES, NASA Ames Research Center, Moffett Field, Calif.

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Dr. JOHN LAUFER, Jet Propulsion Laboratory, California Institute of Technology, Pasadena 3, Calif.

Mr. WERNER K. DAHM, NASA George C. Marshall Space Flight Center, Huntsville, Ala.

Dr. R. KENNETH LOBB, U.S. Naval Ordnance Laboratory, Silver Spring, Md.

Mr. ALFRED GESSOW, NASA Headquarters, *Secretary*

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Mr. CONRAD A. LAU, Advanced Systems Engineering Manager, Aeronautics Division, Chance Vought Corp., Post Office Box 5907, Dallas 22, Tex.

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Mr. ROBERT L. LICHTEN, Chief Experimental Project Engineers, Bell Helicopter Co., Division of Bell Aerospace Corp., Post Office Box 482, Fort Worth 1, Tex.

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Mr. A. D. RIEDLER, Aerodynamics Group Engineer, San Diego Division, General Dynamics Corp., San Diego 12, Calif.

Maj. JACK N. HOFFMAN, USA, Assistant Chief, Research Division, Office of the Chief of Transportation, Department of the Army, Washington 25, D.C.

Mr. C. C. WEISSMAN, Technical Analysis and Advisory Group (07T5), Office of Deputy Chief of Naval Operations (Development), Department of the Navy, 5 E 587 The Pentagon, Washington 25, D.C.

Mr. G. L. DESMOND, Bureau of Naval Weapons, RAAD–3, Department of the Navy, Room 1 W 52, Washington 25, D.C.

Col. JOSEPH W. HOWELL, USAF, Chief, Aerospace Division, AFDRT–AS, U.S. Air Force, 4 C 343 The Pentagon, Washington 25, D.C.

Mr. HAROLD D. HOEKSTRA, Chief Project Officer for Transports, Bureau of Flight Standards, Federal Aviation Agency, Washington 25, D.C.

Mr. JOHN STACK, NASA Langley Research Center, Langley Field, Va.

Mr. R. G. ROBINSON, NASA Ames Research Center, Moffett Field, Calif.

Mr. D. E. BEELER, NASA Flight Research Center, Edwards, Calif.

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Mr. JAMES J. FAGAN, Chief Advisor to Assistant Chief of Staff, Research and Development, Army Ordnance Missile Command, Redstone Arsenal, Ala.

Capt. ROBERT F. FREITAG, USN, Bureau of Naval Weapons, RT, Department of the Navy, Room 3716, Washington 25, D.C.

Dr. R. E. WILSON, Associate Technical Director for Aeroballistics, U.S. Naval Ordnance Laboratory, Silver Spring, Md.

Col. J. L. MARTIN, Jr., USAF, Office of Missile and Satellite Systems, Office of Secretary of the Air Force, SAFMS, Department of the Air Force, 4C968 The Pentagon, Washington 25, D.C.

Mr. WILLIAM E. LAMAR, Chief, Dyna-Soar Engineering Office, Directorate of Systems Engineering, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio.

Mr. JOHN BECKER, NASA Langley Research Center, Langley Field, Va.

Mr. H. JULIAN ALLEN, NASA Ames Research Center, Moffett Field, Calif.

Mr. EUGENE J. MANGANIELLO, NASA Lewis Research Center, 21000 Brookpark Road, Cleveland 35, Ohio.

Mr. HUBERT M. DRAKE, NASA Flight Research Center, Edwards, Calif.

Mr. HARRIS M. SCHURMEIER, Jet Propulsion Laboratory, California Institute of Technology, Pasadena 3, Calif.

Mr. M. A. FAGET, NASA Space Task Group, Langley Field, Va.

Dr. ERNEST D. GEISSLER, NASA George C. Marshall Space Flight Center, Huntsville, Ala.

Mr. RALPH W. MAY, NASA Headquarters, *Secretary*

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Appendix I

Research Grants and Contracts Initiated From Oct. 1, 1960, Through June 30, 1961

[Contracts have prefix NAS; grants have prefix NsG; transfers of funds to Government laboratories have prefix NTF or R. Earlier grants and contracts are listed in Appendix K of the "Fourth NASA Semiannual Report to Congress"]

State and grant or contract No.	Organization and purpose	Investigator	Amount
ALABAMA			
NAS8-1548	Auburn Research Foundation, Inc. Conduct research to develop methods for solving problems associated with space vehicles of high and low thrust.		$19,867
NAS8-880	University of Alabama. Conduct theoretical study of recombination effects as related to electrical noise generation.		6,688
NAS8-1503	University of Alabama. Conduct research on the theoretical physics of ion beam propulsion.		53,262
NAS8-1506	University of Alabama. Conduct research to develop methods for solving problems associated with space vehicles of high and low thrust.		25,425
NAS8-1517	University of Alabama. Conduct a method for correlating elevated temperature fatigue data.		9,250
NAS8-1519	University of Alabama. Conduct study of transient heat transfer problems.		14,999
NAS8-1646	University of Alabama. Research in topological dynamics and related fields.		64,329
ARIZONA			
NsG-120	University of Arizona. Research on generation, detection, and quantitative measurement of ultra-long-wavelength X-rays.	R. W. G. Wyckoff	46,000
CALIFORNIA			
NASr-8	Astro Research Corp. A theoretical and experimental study of toroidal filamentary pressurized structures based on isotensoid design concepts, including initial studies of failure mechanisms, collapsibility and possible application of isotensoid concepts to the design of space structures.	H. R. Schuerch	51,140
NASr-17	Beckman Instruments, Inc. A feasibility and design study of a gas chromatograph for analysis of closed atmospheres. The study will include considerations of physical limitations and power requirements for use in manned space capsules.	M. R. Burnell	19,832
NsG-40	California Institute of Technology. Investigation of fluid mechanics of rarified gases by extending shock techniques into the low-pressure regime.	H. P. Liepmann	120,000

Research Grants and Contracts Initiated From Oct. 1, 1960, Through June 30, 1961—Continued

State and grant or contract No.	Organization and purpose	Investigator	Amount
CALIFORNIA—con.			
NsG-56	California Institute of Technology Investigation of the problems of lunar and planetary exploration.	H. Brown	$86,850
NsG-151	California Institute of Technology Conduct investigation of magnetic fields and energetic charged particles in planetary exospheres and interplanetary space.	Leverett Davis, Jr.	10,000 3,000
NASr-35	Corbin-Farnsworth, Inc. Study and development of remote blood pressure monitoring transducer.	Thomas Corbin	24,500
NASr-23	NORAIR (Northrop) Theoretical investigation of fluid behavior under zero-gravity conditions.	E. T. Benedikt	19,492
NASr-21(01)	Rand Corp. (a) Conduct studies of economic and international policy questions associated with communication satellites; (b) conduct studies of the economic implications of meteorological satellites.		218,801
NASr-21(02)	Rand Corp. Conduct (a) studies of operational factors and economic potential of passive spherical communication satellite systems; conduct (b) studies of operational factors and economic potential of 24-hour active communication satellite systems.		183,650
NASr-21(03)	Rand Corp. Establish criteria whereby the significance of time-variable coefficients in the stability and dynamic load equations of boost vehicles may be determined and defining adequate analytical techniques for their application to booster vehicle design; (b) examine the effects of the time-variable aerodynamic environment.	D.G.B. Edelen	54,060
NASr-38	Stanford Research Institute Survey and evaluate high-energy propellant combinations, including liquid mono-, bi-, and tripropellant, hybrid and tribrid systems concepts, to indicate potential suitability for NASA-type missions.	R. F. Muraca	325,526
NASw-80	Stanford Research Institute A theoretical investigation of low-energy electronic, ionic, and atomic impact phenomena.	C. J. Cook	48,200
NsG-81	Stanford University "Cytochemical Studies of Planetary Microorganisms."	J. Lederberg	380,640
NsG-111	Stanford University Experimental and theoretical investigation of the ability of human operators to perform tasks under controlled conditions.	John E. Arnold	18,538
NsG-121	Stanford University Conduct a radar study of meteors during satellite count periods, including data collection and reduction to a form suitable for comparison with satellite counts.	Von R. Eshleman	11,000
NsG-133	Stanford University Basic studies on space vehicle attitude control systems.	R. H. Cannon	76,500
NAS8-1509	Stanford University Conduct a study of systems for space propulsion.		50,000

Research Grants and Contracts Initiated From Oct. 1, 1960, Through June 30, 1961—Continued

State and grant or contract No.	Organization and purpose	Investigator	Amount
CALIFORNIA—con.			
NsG-72	University of California Plastic properties of ceramic systems (Cont. of NASw-10).	J. A. Pask	$29,500
NsG-122	University of California A search for periodic solutions, and methods for determining their long range stability, to problems of satellite motion around the triaxial earth.	Rene DeVogelaere	13,000
NsG-126	University of California Biochemical Activities of Terrestrial Micro-organisms in Simulated Planetary Environments.	S. Silver	173,800
NsG-131	University of California Solar Activity and Forecasting of Solar Cosmic Ray Emissions.	K. A. Anderson	19,750
NsG-139	University of California Research on techniques and instrumentation for measurement of physiological variables in mammals under space-flight conditions.	H. B. Jones	99,725
NsG-145	University of California Conduct research on the nuclear techniques for chemical analysis of lunar surface materials.	S. Silver	105,000
NASr-26	University of California Conduct research on low-energy cosmic radiation from the sun.	K. A. Anderson	99,498
NAS8-850	University of California Conduct investigation of ablation materials subjected to low heating rates.		14,250
COLORADO			
NASr-37	Stanley Aviation Corp Collect and analyze data, construct mathematical models with 1, 2, or more degrees of freedom, and deduce body tolerances for humans subjected to abrupt acceleration.	P. R. Payne	49,512
NsG-136	University of Colorado High Altitude Observatory Research on the physics of solar flares and the relationships of solar corpuscular emissions to optical and radio features of the sun.	J. W. Warwick	48,000
NsG-143	University of Denver Conduct research on the nucleate boiling process for heat transfer in a very weak gravitational field, at subsaturation liquid temperatures.	W. G. Harrach	34,800
CONNECTICUT			
NsG-138	Yale University Research on low-power low-speed data storage and processing techniques.	R. C. Barker	30,000
DISTRICT OF COLUMBIA			
NASw-128	Aerospace Medical Association Publication and distribution of current medical abstracts in "Aerospace Medicine."		200 4,940
R-19	Armed Forces Institute of Pathology Research on post mortem chemical analysis of biological material for establishing the ante mortem status of individuals in closed space systems.	F. M. Townsend	24,600

State and grant or contract No.	Organization and purpose	Investigator	Amount
DISTRICT OF COLUMBIA—con.			
R-26	Armed Forces Institute of Pathology Conduct studies on the brains of mice and of one monkey to be exposed to cosmic radiation in high-altitude balloon flights.	Martin A. Ross	$27,286
R-7	Bureau of Naval Weapons Liquid Propellant Information Agency collection, cataloging, and dissemination of technical information on liquid rocket propellants and liquid propellant rocket engines.		37,300
R-11	Bureau of Naval Weapons Partial support of further experimental and theoretical studies of combustion instability in liquid rocket motors.	L. Crocco	120,000
R-16	Bureau of Naval Weapons Joint Agencies support of the Solid Propellant Information Agency at the Johns Hopkins University.		10,000 10,000 20,000
R-29	Bureau of Naval Weapons Initiate work on prototype capsule and associated instrumentation necessary to make automatic hemodynamic measurements on monkeys for as long as 48 hours.	Nello Pace	50,000
NsG-125	Catholic University of America Dynamics of solid-propellant rocket motors.	J. H. Baltrakonis	38,227
NASr-39	National Science Teachers' Association Assemble and evaluate the necessary information; develop and publish a series of 5 paperback books on topics of interest to NASA.	M. Gardner	17,500
R-9	Naval Research Laboratory Research on ultraviolet spectroscopy using high-temperature plasma sources.	Alan C. Kolb	75,000
R-21	Naval Research Laboratory Conduct measurement of the optical constants of materials in the extreme ultraviolet, including construction of a reflectometer for use with existing vacuum monochromators.		90,000
R-24	Navy—Bureau of Medicine and Surgery Research on the diurnal periodicity of physiological functions and of performance level; including studies of the effects of removing, or of changing the period or the phase of, environmental time indicators.	B. B. Weybrew	125,735
R-23	Office of Naval Research Reimbursement for balloons, launching services, and related expenses in connection with high-altitude balloon measurements of the electron, low-energy proton, and alpha-particle spectrum of primary cosmic radiation.		49,800
NASr-10	Resources Research, Inc Research on radioisotopic methods for detecting the presence and monitoring the metabolic activity of micro-organisms on an extraterrestrial body, and design and build a prototype of the detection and monitoring apparatus.	Gilbert V. Levin	141,173
NsG-51	Smithsonian Institution Design and construction of equipment for an ultraviolet sky survey to be conducted from a stabilized satellite (Cont. NsG-7-59).	F. L. Whipple	480,543

Research Grants and Contracts Initiated From Oct. 1, 1960, Through June 30, 1961—Continued

State and grant or contract No.	Organization and purpose	Investigator	Amount
DISTRICT OF COLUMBIA—con.			
NsG-87	Smithsonian Institution Optical satellite tracking program.	Fred L. Whipple	$2,000,000 1,500,000
NsG-35-60	Society of Photographic Scientists Conduct volunteer photographic tracking program.		35,534
R-12	U.S. Air Force (Headquarters) Phase I, biological effects of cosmic rays in extremely high altitude operations. Phase II, biological dosimetry of ionizing space radiations.		130,070
NASr-45	Cosmic, Inc Analytical investigation of physical phenomena in a rotating-cup electrostatic nozzle suitable for a colloidal propulsion system.	Dominique Gignoux	5,900
R-25	Department of the Air Force Obtain complete dynamic physiological and behavioral baseline data on chimpanzees correlatable to man and for increasing the Aeromedical Field Laboratory's capability to perform additional chimpanzee baseline studies and provide chimpanzees to support NASA programs.		490,000
R-8	Department of the Navy—Bureau of Medicine and Surgery. Research into basic physiological mechanisms which defend the human body against heat and cold, and determine the extent and efficiency of energy transformations in the human body and in isolated body constituents at the molecular level.	T. H. Benzinger	62,120
NsG-141	National Academy of Sciences Support of the 11th General Assembly of the International Astronomical Union.		25,000
R-6	National Bureau of Standards Experimental research on thermionic materials, including selection of materials, construction of apparatus, and preliminary measurements of vaporization and thermionic omission.	Alan D. Franklin	50,000
R-13	National Bureau of Standards Research on the physical properties of hydrogen, techniques for determining engineering data on cryogenic fluids, materials and design principles for cryogenic systems, and compilation of low-temperature data from the literature.		235,000
R-14	National Bureau of Standards Effect of surface reactions on fatigue failure. (Cont. NTF-97).	J. A. Bennett	28,000
R-18	National Bureau of Standards Support of University of Hawaii-University of Colorado research on zodiacal light and airglow.	F. E. Roach	25,000
H-3547	National Bureau of Standards Conduct investigation of the total and spectral emissivities of materials at high temperatures.		15,000
S-4701-G	National Bureau of Standards Study of the spectra of trapped atoms and of low molecular weight molecules.	Arnold M. Bass	24,000
R-27	National Institutes of Health Procurement of planchets for resources research incorporated contract NAS-10.		270

State and grant or contract No.	Organization and purpose	Investigator	Amount
DISTRICT OF COLUMBIA—con.			
R-22	National Science Foundation Partial support for National Science Foundation and National Academy of Sciences of the Space Science Board.		$95,000
NTF-131	National Science Foundation Partial support of the ICSU Committee on Space Research (COSPAR).		5,000
R-17	Weather Bureau Squall line and severe local storm research project, including the engineering and installation of vertical motion probes of 4 research aircraft, flight-data processing, and operational services.		59,000
FLORIDA			
R-20	Naval School of Aviation Medicine Triaxial human ballistrocardiogram in zero g environment.	W. C. Hixson	36,000
NAS8-1594	University of Florida Conduct study of the changes occurring in the metal structure during ultrasonic welding.		38,667
GEORGIA			
NsG-123	Georgia Institute of Technology Chemical reactions at cryogenic temperatures as as preparative techniques for highly endothermic chemical species.	Henry A. McGee	71,244
NAS1-532	Georgia Tech Research Institute Conduct studies for the preparation of a mathematical procedure for determining the drag forces acting on an artificial satellite.	E. L. Davis	38,292
NAS8-848	Georgia Tech Research Institute Development work for pigment particle size preparation.		18,548
HAWAII			
NsG-135	University of Hawaii Study on zodiacal light selected lines in the airglow spectrum.	R. Steiger	120,039
ILLINOIS			
NASr-1	Armour Research Foundation Research on the use of fluorescent and phosphorescent materials to improve the efficiency of utilization of solar radiation by biological waste recycling systems.	John Rosinski	4,358
NASr-22	Armour Research Foundation Life in extraterrestrial environments.	Richard Ehrlich	27,766
NASr-29	Armour Research Foundation Effects of solar plasma and electromagnetic radiation on thin films and surfaces.	L. Reiffel	75,000
NAS8-20	Northwestern University Rsearch and development work on the application of electronic images conversion techniques to the tracking of space probes and other astronomical objects.		34,975

Research Grants and Contracts Initiated From Oct. 1, 1960, Through June 30, 1961—Continued

State and grant or contract No.	Organization and purpose	Investigator	Amount
ILLINOIS—con.			
NsG-118	University of Chicago. Theoretical studies of the temperature balance of Venus, properties of the interplanetary gas, and photochemical and ionospheric processes in planetary atmospheres.	J. W. Chamberlain	$25,280
NsG-127	University of Chicago. Chemical Analysis of Material on the Moon and Planets Using Rutherford Scattering of Charged Particles.	Anthony Turkevich	30,597
NsG-128	University of Chicago. Acquisition and installation of low-level gamma-counting equipment for research on cosmic-ray-induced radioactivity in meteorites.	A. Turkevich	27,200
NsG-144	University of Chicago. Conduct high-altitude balloon measurements of the electron, low-energy proton, and alpha-particle spectrum of the primary cosmic radiation during 1961.	Peter Meyer	6,200
INDIANA			
NsG-140	Purdue Research Foundation. Conduct research on basic mechanisms and phenomena associated with heat transfer between a liquid bed and an inert gas bubbling through it.	M. J. Zucrow	64,565
MARYLAND			
NASr-25	Aeronca Manufacturing Corp. Optimal feedback control system by the adjoint system.	R. W. Bass	25,620
NASr-13	Engineering-Physics Co. Research on an induction flowmeter for use with electrically nonconducting fluids. The research will include consideration of fluid and material properties, preliminary design studies and error analyses, and design of a prototype suitable for development.	Vincent J. Cushing	8,747
R-10	Naval Medical Research Institute. Investigate the mechanisms of injuries by exposure to vibration; evaluate vibration as a physiological stress; and establish safety and tolerance limits for the exposure of personnel to mechanical vibration.	D. E. Goldman	107,300
MASSACHUSETTS			
NASr-16	Allied Research Associates, Inc. Review of biological mechanisms for application to instrument design.	Alfred Kornfield	56,901
NASw-184	Harvard University. Research and development of instrumentation for the observation of solar radiation from satellite vehicles (Cont. of NASw-55—U. Michigan).	Leo Goldberg	100,000
NASr-33	Liquid Metals, Inc. Conduct basic research on the fundamental electrodynamic and hydrodynamic phenomena involved in electromagnetic pumping of liquid metals.	G. R. Findlay	45,000

Research Grants and Contracts Initiated From Oct. 1, 1960, Through June 30, 1961—Continued

State and grant or contract No.	Organization and purpose	Investigator	Amount
MASSACHUSETTS—continued			
NsG-117	Massachusetts Institute of Technology. Research on mechanisms of alloy strengthening by fine particle dispersions, with particular emphasis on selective reduction of nonrefractory oxides, stability of metal-metal oxide systems, and solid-solution matrices in metal-metal oxide alloys.	Nicholas J. Grant	$17,500
NsG-149	Massachusetts Institute of Technology. Conduct research on vibratory-output angular motion sensors.	G. C. Newton, Jr.	78,861
NAS4-86	Massachusetts Institute of Technology. Investigation of the X-15 inertial guidance system.		5,750
NAS9-103	Massachusetts Institute of Technology. Study of a guidance and navigation system (Project Apollo).		100,000
NASr-41	National Research Corp. Research on the effects of simulated space environments on the viability of micro-organisms.	W. H. Keller	61,900
NASr-18	Sylvania Electronic Systems. Theoretical research on the behavior of hydromagnetic waves in an electrically conducting fluid of infinite extent in the presence of a constant dipole magnetic field.	John Carstoiu	9,943
NASr-20	Tracerlab, Inc. The effects of nuclear radiation in liquid hydrogen for their possible applications including the metering of liquid hydrogen flow and density.	D. Chleck	38,350
NASw-168	United Research, Inc. Study of the relations of groups to the process of policy formation and public information within NASA.	D. V. d'Arbeloff	7,894
NASw-205	United Research, Inc. Study of the regulatory aspects of the commercial application of communications satellites.		25,447
MICHIGAN			
NsG-86	University of Michigan. Study of particle dynamics under conditions which exist in rockets.	R. B. Morrison	28,352
NsG-115	University of Michigan. Study of microwave, radio frequency, and ionizing radiation interactions in solids.	Chihiro Kikuchi	50,000
NsG-124	University of Michigan. Research on heat-resistant alloys.	J. W. Freeman	50,000
NsG-132	University of Michigan. Conduct research on dynamics of buckled panels.	E. F. Masur	18,375
NASr-15	University of Michigan. Research on the use of electronic and mechanical apparatus and instrumentation for rockets and satellites.	L. H. Brace	45,000
NASw-54	University of Michigan. Astronomical experiments in satellites—radio astronomy TASK No. 1.	F. T. Haddock	179,000
NASw-55	University of Michigan. Preliminary investigation of techniques and instrumentation for measurement of the ultaviolet solar emission spectrum.	Leo Goldberg	3,000

Research Grants and Contracts Initiated From Oct. 1, 1960, Through June 30, 1961—Continued

State and grant or contract No.	Organization and purpose	Investigator	Amount
MICHIGAN—con.			
NASw-115	University of Michigan. Rocket grenade instrumentation program.	Harold F. Allen	$200,000
NASw-133	University of Michigan. Measurement of atmospheric pressure in the region between the earth and the moon.	D. R. Taeusch	50,000
NASw-138	University of Michigan. The development of rocket instrumentation commenced under Contract NASw-4 for the measurement of atmospheric pressure, density, temperature, and composition in the altutude region 100–200 kilometers. Test instrumentation and synoptic version of system in rockets fired at Wallops Island.	L. M. Jones	203,420
NASw-139	University of Michigan. Design, develop, construct, deliver, and supervise installation of 2 instrumented nose cones containing Langmuir probes, control units, and necessary telemetry, and conduct sounding rocket experiment and studies of the ionosphere.	W. G. Dow	125,000
NASw-140	University of Michigan. Research on advanced measuring techniques of atmospheric and surface phenomena using radio meters sensitive in the visible and near infrared regions of the spectrum.	F. L. Bartman	270,000
NAS8-825	University of Michigan. Investigation and study of transient heat transfer.		40,000
NASr-24	Wyandotte Chemicals Corp. Conduct research, by absorption spectroscopy techniques, on high-energy compounds formed by the interactions of free radical trappers and with atoms excited to metastable energy levels.	L. E. Kuentzel	42,579
MINNESOTA			
NASr-27	Minneapolis-Honeywell. Perform analytical studies of advanced optimum-control theories for solutions to the general class of problems encountered in the control of large liquid-fueled aerospace vehicles.		154,351
NsG-137	University of Minnesota. Research on radiation heat transfer.	E. M. Sparrow	40,121
NASr-11	University of Minnesota. Research on the effects of earth satellite environment and launching stresses on biological metabolism, including ground-based studies, design and construction of instrumentation for satellite-borne studies, and analysis of the results of the flight experiment.	Allan H. Brown	23,173
NASw-56	University of Minnesota. Cosmic-ray instrumentation in satellite and planetary probe experiments.	J. R. Winckler	100,000
MISSOURI			
NAS8-810	Midwest Research Institute. Conduct theoretical research on loading of missiles due to atmospheric turbulence and wind shear.		40,047

Research Grants and Contracts Initiated From Oct. 1, 1960, Through June 30, 1961—Continued

State and grant or contract No.	Organization and purpose	Investigator	Amount
MISSOURI—con.			
NAS8-835	Midwest Research Institute. Conduct investigation of thermal properties of materials ranging from −250° to 1,500° C.		$92,945
NEW HAMPSHIRE			
NASw-155	University of New Hampshire. Develop, construct, and test 4 magnetometer instruments suitable for use on a satellite to determine the magnitude and direction of the earth's magnetic field and analyze telemetered data from the instrument.	L. J. Cahill	31,280
NEW JERSEY			
NsG-69	Princeton University. The use of television techniques with telescopes above the atmosphere.	M. Schwarzschild	250,000
NASr-36	Princeton University. Conduct research on transient pressure transducers for use in jet propulsion research.	Howland B. Jones	50,000
NASr-42	Princeton University. Design, construct, and test a prototype temperature-compensated rugged high-resolution scanning spectrometer suitable for use in the Orbiting Astronomical Observatory spacecraft to be fabricated by the Grumman Aircraft Corp.	Lyman Spitzer	100,000
NsG-130	Stevens Institute of Technology. Research on electrohydrodynamics of superfluid helium.	Jack Fajans	27,698
NEW MEXICO			
NsG-142	New Mexico State University. Photographic patrol and study of the physical conditions on the moon and planets.	Clyde W. Tambough	44,291
NsG-129	University of New Mexico. Investigate radar echoes from the moon and planets, using methods and data from earth radar-return studies.	R. K. Moore	24,918
NASw-99	University of New Mexico. Design, construction, and testing of a Cerenkov counter and associated circuitry to measure the energy spectrum of high-energy gamma rays. Test and calibrate the equipment by synchrotron or balloon techniques, and assemble instrument packages for use in satellites.	Christopher P. Leavitt.	35,000
NEW YORK			
NASr-44	Bell Aerosystems Co. Conducting research on zero-gravity expulsion techniques.	Anthony E. Mirti	99,030
NsG-112	Columbia University. Methods for determining blood flow through intact vessels of experimental animals under conditions of gravitational stress and in extraterrestrial space capsules.	G. H. Humphreys II	56,950
NAS5-670	Cornell Aeronautical Laboratory. Study of the equilibrium and nonequilibrium flow of high-temperature hydrogen through jet nozzles.	F. K. Moore	232,162

Research Grants and Contracts Initiated From Oct. 1, 1960, Through June 30, 1961—Continued

State and grant or contract No.	Organization and purpose	Investigator	Amount
NEW YORK—con.			
NAS8-823	Cornell Aeronautical Laboratory, Inc. Research relative to the application of shock-tube techniques to the study of base heating of rocket-motor vehicles.		$194,442
NAS8-1520	Cornell Aeronautical Laboratory, Inc. Conduct research relative to the development of equipment for acquiring high-resolution measurements of wind velocity and vertical wind shear in the troposphere.		180,000
950061	Cornell Aeronautical Laboratory. Study the requirements for the ground data processing system of lunar orbiter.		10,743
NsG-116	Cornell University. Kinetics of chemical reactions in gases at high temperatures utilizing shock-tube and other gas dynamic techniques.	S. H. Bauer	51,000
NsG-119	Cornell University. Experimental laboratory research on lunar surface destruction, migration and physical and chemical properties due to X-ray and proton irradiation.	T. Gold	117,170
NsG-155	Dudley Observatory. Collection and analysis of micrometeorites.	Curtis L. Hemenway	48,000
NASw-72	Marlin-Rockwell Corp. An experimental investigation of methods for reducing the amount of end fiber in bearing components, and of the effect of the reduction on the life of bearings and bearing balls.	A. S. Irwin	61,988
NsG-76	New York University. A theoretical research in the fields of molecular quantum mechanics and transport properties of diatomic molecules.	R. C. Sahni	56,900
NASw-31	New York University. Investigation of the neutrons produced by cosmic radiation at high altitudes, including the instrumentation of two Aerobee-Hi rockets to be flown by NASA.	S. A. Korff	32,194
NsG-48	Rensselaer Polytechnic Institute. Investigation of the properties of gaseous plasmas by microwave techniques.	E. H. Holt	73,980
NsG-100	Rensselaer Polytechnic Institute. Interdisciplinary materials research.	S. E. Wiberley	300,000
NsG-113	Rensselaer Polytechnic Institute. Models of interstellar dust clouds and extinction and polarization in the ultraviolet.	J. M. Greenberg	66,900
NASr-30	Sperry Gyroscope. Conduct research on an electrostatic technique for low-level acceleration measurement, including theoretical study.	E. B. Hammond	85,814
NASr-43	Syracuse University Research Institute. Conduct evaluation and screening tests on notch sensitivity, creep, and fatigue of selected high-strength structural alloys for a Mach 3 transport plane.	Volker Weiss	50,300
NAS8-802	Syracuse University. Research and development work pertaining to thermal cycling under constant load of high-strength metal alloys.		20,250

State and grant or contract No.	Organization and purpose	Investigator	Amount
NEW YORK—con.			
NASr-14	University of Rochester. Optical problems relating to an orbiting astronomical observatory.	Harold Steward	$120,000 24,500
NASw-107	University of Rochester. Development research on solid-state photodetector and associated optical materials.	Harold S. Stewart	152,000
NASr-31	Wilmot Castle Co. Perform research on sterilization of space-probe components by dry heat, irradiation, or other techniques.		106,879
NORTH CAROLINA			
NsG-152	Duke University. Conduct research on satellite electrical power conversion systems and circuit protection.	Thomas G. Wilson	28,902
NASr-40	Research Triangle Institute. Research for an abstracting and review service for technical literature on reliability for scientists and engineers.	Gertrude M. Cox	39,152
NAS8-1528	University of North Carolina. Conduct research to develop methods for solving problems associated with space vehicles of high and low thrust.		32,358
OHIO			
NASr-9	Battelle Memorial Institute. Investigation of electronic components reliability.		58,500
NASw-101	Battelle Memorial Institute. An investigation of impurity elements, structure, and prestrain on the tensile transition temperature of chromium and chromium-rhenium-type derived alloys.	R. I. Jaffee	35,000
NsG-110	Case Institute of Technology. Research to establish methods of systematic structural synthesis.	L. A. Schmit, Jr.	74,826
NASr-12	General Electric Co. Development of analytical methods for determination of oxygen in potassium metal.	H. Kirtchik	49,845
NsG-74	Ohio State University. Research on receiver techniques and detectors for use at millimeter and submillimeter wavelengths.	T. E. Tice	30,000 30,000
N-28111	Ohio State University. Electromagnetic investigation of the properties of the surface of the moon.	Thos. E. Tice	50,000
OREGON			
NASr-19	Linfield Research Institute. Conduct research on sputtering phenomena, surface stability and voltage breakdown for alkali-coated refractory electrodes.	W. P. Dyke	81,765
PENNSYLVANIA			
R-15	Franklin Institute—ONR. Joint agencies program on research on gas-lubricated bearings (Cont. of HS-82 and NTF-100).	D. D. Fuller	5,000

Research Grants and Contracts Initiated From Oct. 1, 1960, Through June 30, 1961—Continued

State and grant or contract No.	Organization and purpose	Investigator	Amount
PENNSYLVANIA—con.			
NASr-32	General Electric Co. Conduct a theoretical and analytical investigation of the thermodynamic and transport properties and stagnation point heat transfer in partially ionized air.	S. M. Scala	$64,623
NASr-34	General Electric Co. Evaluation of various approaches to the problem of shielding space vehicles from ionizing radiation.	N. F. Dow	75,622
NsG-147	Mellon Institute of Industrial Research. Conduct research on visoelastic behavior of polymers at long times.	Donald J. Plasek	49,211
NsG-114	Pennsylvania State University. The study of ionospheric electron content and distribution using the satellite doppler effect.	William J. Ross	127,612
NsG-134	Pennsylvania State University. A preliminary investigation of a rocket and separating capsule method of measuring electron density in the ionosphere.	J. Nisbet	25,282
NsG-84	Temple University. The production of hypervelocity particles of small size and to increase the sensitivity of micrometeorite detection techniques.	J. Lloyd Bohn	34,928
TEXAS			
NsG-6	Rice University. Research on the physics of solid materials, including study of the basic laws governing the behavior of solids at high temperatures.	Franz Brotzen	300,000
NASw-146	Southwest Research Institute. Studies of fuel sloshing by use of small models.	H. N. Abramson	40,000
VIRGINIA			
NsG-156	Medical College of Virginia. Mechanisms of control of cerebral circulation.	John L. Patterson, Jr.	48,000
NAS8-831	University of Virginia. Investigation of reaction torquing of satellites with freely supported spheres.		40,000
WISCONSIN			
NASw-65	University of Wisconsin. Research work which is intended to result in the automatic reduction and analysis of data from meteorological satellites.	V. E. Suomi	100,000
FOREIGN			
NsG-54	University of Auckland. An investigation of the propagation of radio signals from artificial satellites.	H. A. Whale	15,000
NsG-45	University of Heidelberg. The recording and mailing of information from satellite(s) which shall be placed in orbit around the earth by the Administration.	Otto Haxel	14,000
NASw-68	University of Manchester (England). Services of the radio telescope at Jodrell Bank in cooperation with NASA in tracking several space probes and satellite vehicles.		125,000

Appendix J

R and D Contracts or Amendments Thereto of $100,000 and Over Shown by Program[1]

(Awarded Oct. 1, 1960, through Mar. 31, 1961)[2]

ACTIVITY: NASA HEADQUARTERS

Program	Contractor and contract number	Purpose	Approximate obligations
Advanced research programs; support of NASA plant.	Norwood Studios, Inc.; NASw-204.	Motion-picture services to cover "Mercury Project" and "Origin of Life Series."	$201,747
Research grants and contracts.	General Dynamics Corp., Electric Boat Division; NASw-95.	Research on photosynthetic gas exchanger for spacecraft.	147,597
	Isomet Corp., NASw-117	Research on closed chemical systems for reduction of carbon dioxide to oxygen.	100,877
	Department of the Navy, Bureau of Medicine and Surgery; NTFr-10.	Investigate the mechanisms of injuries produced by exposure to vibration.	107,300
	Department of the Navy, Bureau of Weapons; NTFr-11.	Experimental and theoretical studies of combustion instability in liquid-rocket motors.	120,000
	Department of the Air Force, Headquarters; NTFr-12.	Support of Air Force radiobiological research tasks.	130,070
	Department of Commerce, Bureau of Standards; NTFr-13.	Research on physical properties of hydrogen, techniques for determining engineering data on cryogenic systems, and compilation of low temperature data.	130,000
	Leland Stanford, Jr., University, Board of Trustees; NSG-81-60.	Cytochemical studies of planetary micro-organism.	380,640
	Florida State University; NsG-105-61.	Chemical matrices for life	103,804
Scientific investigations in space scientific satellites.	Princeton University Trustees; NASr-3.	Instrumentation for detecting, measuring, and recording the spectrum of an early-type star from a rocket, and preparation of such instrumentation for 3 rocket flights.	300,000
	University of Minnesota; NsG-109-61.	High-altitude balloon monitoring for cosmic rays and solar terrestrial phenomena.	105,000
Lunar and planetary exploration.	University of California; NsG-97-60.	Studies on inert gases in meteorites, lunar gamma-ray experimentation, and X-ray diffraction development.	140,801
	University of California; NsG-98-60.	Research on cosmogenic radioactivity of meteorites, cosmic abundances of the elements, and structure and composition of extraterrestrial objects.	175,362
Space propulsion technology; Nuclear systems technology.	The Rand Corp.; NASr-2	Study to indicate the place of nuclear rockets in the national space program.	129,173
	Department of Commerce, Bureau of Standards; NTFr-13.	Research on physical properties of hydrogen, techniques for determining engineering data on cryogenic systems, and compilation of low-temperature data.	105,000

See footnotes at end of table.

R and D Contracts or Amendments Thereto of $100,000 and Over Shown by Program [1]—Continued

Program	Contractor and contract number	Purpose	Approximate obligations
Supporting activities; tracking and data acquisition.	Council for Scientific and Industrial Research (South Africa); NASw-156.	Services in connection with the NASA deep-space exploration program.	$125,000
	Council for Scientific and Industrial Research (South Africa); NASw-208.	Services in connection with a radio tracking facility (Minitrack).	105,000
ACTIVITY: LANGLEY RESEARCH CENTER			
Advanced research programs; support of NASA plant.	Department of the Navy, Bureau of Weapons; L-86693 G.	Motors rocket X254-A-2 and X248-A-6 for flight vehicles at Wallops Island.	$224,000
Manned space flight	Massachusetts Institute of Technology, Lincoln Laboratory; NAS1-229.	Engineering investigations, plans and participation in phases of ground instrumentation testing for Project Mercury range.	140,000
	Western Electric Co., Inc., defense projects; NAS1-430.	Project Mercury tracking and ground instrumentation.	3,197,477
	North American Aviation, Inc., Missile Division; NAS5-57.	7 transport vehicles and 1 rocket launcher.	233,465
	ITT Kellogg Space Communications Laboratory; NAS5-154.	90 receivers, homing pulse and CW modes. Project Mercury, recovery operations.	310,612
	Department of the Navy, Bureau of Aeronautics; L-86387.	Space parts for AN/FPS-16 radar at Coopers Island, Bermuda.	125,000
Vehicle development; Scout.	Chance Vought Corp.; NAS1-249.	Airframes for the NASA Scout	252,275
	Chance Vought Corp., Vought Astronautics Division; NAS1-553.	Design, develop, fabricate 609A vehicle launchers and ground-support equipment.	746,804
	Chance Vought Corp., Vought Astronautics Division; NAS1-900.	Design, fabricate, ground testing, instrumentation and preparation for launch of 5 Scout research vehicles.	3,140,000
	Minneapolis-Honeywell Regulator Co., Aeronautical Division; NAS5-61.	Guidance and control for NASA Scout and 609A vehicles.	955,596
	Department of the Navy, Bureau of Weapons; L-89844.	Motors, rocket, ALTAIR X-248A5, and ANTARES X-254A1.	120,000
	ARGMA industrial operations; L-89845.	Motors, rocket, XM-33E5	148,361
Supporting activities; tracking and data acquisition.	Massachusetts Institute of Technology, Lincoln Laboratory; NAS1-229.	Engineering investigations, plans, and participation in phases of ground instrumentation testing for Project Mercury range.	370,000

See footnotes at end of table.

R and D Contracts or Amendments Thereto of $100,000 and Over Shown by Program[1]—Continued

ACTIVITY: LEWIS RESEARCH CENTER

Program	Contractor and contract number	Purpose	Approximate obligations
Advanced research programs; support of NASA plant.	General Dynamics Corp., Liquid Carbonics Division; NAS3-1193.	Liquid oxygen, liquid nitrogen, and gaseous oxygen.	$173,050
	Linde Co., Division of Union Carbide Corp.; NAS3-1194.	Liquid oxygen, liquid nitrogen, and gaseous oxygen-	116,680
	Controls for Radiation, Inc.; NAS3-1320 PB.	Services incident to operation of Plum Brook nuclear reactor.	200,000
	Department of the Interior, Bureau of Mines; C-40000.	Helium gas	163,215
	Air Research and Development Command; C-44346.	Liquid hydrogen	660,000

ACTIVITY: GODDARD SPACE FLIGHT CENTER

	Washington Technological Associates, Incorporated NAS5-204.	Electromechanical services with associated assemblies required to perform specific task assignments.	$25,544
	Airtronics, Inc. NAS5-206.	Machine-shop services and materials for specific task assignments.	950
	Naval Weapons Plant; S-5462 G.	In-plant shop services to support NASA Goddard Space Flight Center fiscal year 1961.	550,000
	Naval Research Laboratory; S-7587 G.	Overhead cost for tenancy	439,900
	Department of Agriculture Research Center; S-7655 G.	Refrigeration, electrical services, etc., by Facilities Engineering Division.	100,000
	Department of the Army, Chief of Ordnance; S-10640 G.	Telescope, tracking, type R2, complete with mount, nerves, optics, and control console.	197,008
	Naval Station, Anacostia; S-10843 G.	Rental, utilities, maintenance for Goddard Space Flight Center, fiscal year 1961.	111,000
Scientific investigations in space sounding rockets.	Washington Technological Associates, Inc.; NAS5-204.	Electromechanical services with associated assemblies to perform specific task assignments.	24,232
	Airtronics, Inc.; NAS5-206.	Machine-shop services and materials for specific task assignments.	3,000
	Aerojet-General Corp.; NAS5-216.	Aerobee sounding rockets and associated components.	177,462
	The Regents of the New Mexico College of Agriculture and Mechanic Arts; NAS5-253.	Study on antenna system for Nimbus-type satellites.	100,672
	Zimney Corp.; NAS5-805.	Skylark rocket payloads	159,522
	Naval Research Laboratory; S-8972 G.	Environmental tests in connection with the first NERV flight.	123,524
Scientific satellites	Washington Technological Associates, Inc.; NAS5-204.	Electromechanical services with associated assemblies required to perform specific task assignments.	88,869
	Airtronics, Inc.; NAS5-206.	Machine-shop services and materials for specific task assignments.	125

See footnotes at end of table.

R and D Contracts or Amendments Thereto of $100,000 and Over Shown by Program[1]—Continued

ACTIVITY: GODDARD SPACE FLIGHT CENTER—Continued

Program	Contractor and contract number	Purpose	Approximate obligations
Scientific satellites	Airborne Instruments Laboratory, Division of Cutler-Hammer, Inc.; NAS5-403.	Airborne ground checkout equipment for ionsphere sounder system.	$399,777
	Spectrolab, Inc.; NAS5-614.	Fabrication of solar collectors	173,742
	Grumman Aircraft Engineering; NAS5-814.	Orbiting Astronomical Observatory project.	4,241,100
	Jarrell-Ash Co.; NAS5-851.	Grazing-incidence grating instrumentation for soft X-ray measurements.	101,458
	Space Technology Laboratories, Inc.; NAS-899.	Design and development of the Orbiting Geophysical Observatory spacecraft.	3,600,000
	Ball Bros. Research Corp.; NAS5-976.	Manufacture, integration, testing, and field services associated with OSO (S-16a) satellite project.	100,000
	EPSCO, Inc.; NAS5-1064.	PCM ground stations for checkouts and ground-testing of satellites.	100,000
	Department of Commerce, Bureau of Standards; NTF-84.	Ionosphere electron density studies and computations.	100,000
	Naval Research Laboratory; S-8166 G.	Research and development on the S6 spectrometer protoypes.	150,000
Lunar and Planetary Exploration.	Washington Technological Associates, Inc.; NAS5-204.	Electromechanical services with associated assemblies required to perform specific task assignments.	30,016
Vanguard	Airtronics, Inc.; NAS5-206.	Machine-shop services and materials for specific task assignments.	17,522
atellite applications meteorology.	Washington Technological Associates, Inc.; NAS5-204.	Electromechanical services with associated assemblies required to perform specific task assignments.	14,079
	The Regents of the New Mexico College of Agriculture and Mechanic Arts; NAS5-253.	Study on antenna system for Nimbus-type satellites.	69,384
	Radio Corp. of America, Astro Electronic Products Division; NAS5-478.	Infrared radiation experiment integration, modifications to ground stations, and pre/post launch support for TIROS meteorological satellite.	250,158
	Radio Corp. of America, Astro Electronic Products Division; NAS5-667.	Automatic picture-taking subsystem for Nimbus.	100,000
	International Telephone & Telegraph Corp., ITT Labs Division; NAS5-668.	Design, development, and furnishing high radiation nighttime cloud-cover radiometers.	139,235
	General Electric Co., Missile and Space Vehicle Department; NAS5-746.	Design and development of a stabilization and control subsystem for the Nimbus satellite.	426,500
	Santa Barbara Research Center; NAS5-757.	Medium resolution scanning radiometer for Nimbus meteorological satellite.	343,426

See footnotes at end of table.

R and D Contracts or Amendments Thereto of $100,000 and Over Shown by Program [1]—Continued

ACTIVITY: GODDARD SPACE FLIGHT CENTER—Continued

Program	Contractor and contract number	Purpose	Approximate obligations
Satellite applications meteorology—Con.	Radio Corp. of America, Astro Electronics Division; NAS5-877.	Advanced vidicon camera systems for satellite applications.	$100,000
	California Computer Products, Inc.; NAS5-878.	Satellite clock subsystem	555,075
	General Electric Co.; NAS5-978.	Integration and testing of the Nimbus spacecraft.	575,000
	Department of the Army, Chief Signal Officer; NTF-41.	Meteorological satellite program—Project TIROS.	133,055
	Department of Commerce, Weather Bureau; NTF-60.	Meteorological satellite research	1,171,600
Communications	Douglas Aircraft Co.; NASw-38.	Design, develop, fabricate, acceptance test, deliver, and launch 3-stage Delta vehicle.	147,834
	Space Technology Laboratories, Inc.; NAS5-825.	Engineering to formulate project plan and specifications for an active communications satellite research and development program.	350,000
Manned space flight	General Electric Co., Missile and Space Vehicle Department; NAS5-302.	Feasibility study for an advanced manned spacecraft and system.	250,000
	The Martin Co.; NAS5-303.	Feasibility study for an advanced manned spacecraft and system.	250,000
	General Dynamics Corp., Convair Astronautics Division; NAS5-304.	Feasibility study for an advanced manned spacecraft and system.	250,000
	Air Force Missile Test Center; S-3783 G.	New facilities for Project Mercury at Cape Canaveral.	137,000
Space Propulsion Technology. Solid Rockets.	Department of the Navy, Bureau of Weapons; S-4793 G.	Investigate the feasibility of a multilayer propellant configuration for use in high mass ratio solid rockets.	120,000
Liquid Rockets	North American Aviation, Inc., Rocketdyne Division; NASw-16.	Development of 1500K rocket engine	6,886,201
	Arthur D. Little, Inc.; NAS5-664.	Investigate and derive design data for the stability of liquid propellants in space.	117,874
Nuclear Systems Technology.	North American Aviation, Inc., Rocketdyne Division; NAS5-412.	Development of a liquid-hydrogen-cooled jet nozzle.	332,867
	Lockheed Aircraft Corp.; NAS5-643.	Reactor in-flight test system study	100,000
	The Martin Co.; NAS5-648.	Reactor in-flight test system	100,000
	Cornell University Aeronautical Laboratory; NAS5-670.	Study of the equilibrium and nonequilibrium flow of high temperature.	232,162
	General Electric Co., Flight Propulsion Laboratory; NAS5-681.	Study of heat-transfer coefficients of boiling and condensing sodium and potassium.	200,000
	Atomic Energy Commission; NTF-21.	Hydrogen turbopump systems to be used in Kiwi reactor tests.	3,240,000

See footnotes at end of table.

R and D Contracts or Amendments Thereto of $100,000 and Over Shown by Program [1]—Continued

ACTIVITY: GODDARD SPACE FLIGHT CENTER—Continued

Program	Contractor and contract number	Purpose	Approximate obligations
Space Propulsion Technology	Plasmadyne Corp.; NAS5-651.	1-kilowatt plasmajet rocket engine development.	$111,512
Space Power Technology.	Gulton Industries, Inc.; NAS5-809.	Design, development, and manufacture of storage batteries for future satellites.	127,475
	General Electric Co., Missile and Space Vehicle Department; NAS5-826.	Thermal energy storage program	200,000
Vehicle Development Delta.	Douglas Aircraft Co.; NASw-38.	Design, develop, fabricate, acceptance test, deliver, and launch 3-stage delta vehicle.	7,616,363
Supporting activities; tracking and data acquisition.	Bendix Corp., Bendix Radio Division; NAS5-5w.	Operation and maintenance of NASA satellite tracking stations in United States, South America, Australia, and Newfoundland.	498,000
	Washington Technological Associates, Inc.; NAS5-204.	Electromechanical services with associated assemblies required to perform specific task assignments.	4,238
	Airtronics, Inc.; NAS5-206	Machine-shop services and materials for specific task assignments.	104,844
	The Regents of the New Mexico College of Agriculture and Mechanic Arts; NAS5-253.	Study on antenna system for Nimbus-type satellites.	55,802
	Bendix Corp.; Bendix Radio Division; NAS5-734.	Operation and maintenance of NASA radio tracking facilities within and outside the Continental United States.	1,750,000
	Minnesota Mining & Manufacturing Co.; NAS5-770.	Procurement of magnetic tape for satelite tracking and data transmission.	250,000
	The Sanborn Co.; NAS5-788.	Procurement of permapaper and styli	100,000
	Ampex Corp., Ampex Data Products Co.; NAS5-798.	Magnetic tape recorders, CRT monitor panels, remote control units, and components.	379,904
	General Mills, Inc.; NAS5-905.	General Mills AD/ECS computer equipped with photoreader, punch, typewriter, and console.	160,464
	Department of the Army, Chief of R. and D.; NTF-72.	Support of upper atmosphere research facility at Fort Churchill, Manitoba, Canada.	500,000
	Naval Research Laboratory; S-7201 G.	Computing services under ONR contract.	250,000
	Department of Commerce, Bureau of Standards, Boulder Laboratory; S-9548 G.	Support for the materials to increase power and for inclusion of time information.	103,000
	Air Force Missile Test Center; S-10143 G.	Operation of Antigua Minitrack Station.	100,000
	Department of the Army, Chief Signal Officer; S-10529 G.	Construction of local channel facilities, Alaska, in connection with microwave data link for Nimbus project.	110,000

See footnotes at end of table.

R and D Contracts or Amendments Thereto of $100,000 and Over Shown by Program[1]—Continued

ACTIVITY: WESTERN OPERATIONS OFFICE

Program	Contractor and contract number	Purpose	Approximate obligations
Advanced research programs; support of JPL plant.	California Institute of Technology; NASw-6.	Research and development for propellants, communications, aerodynamics, chemistry, physics, heat, instrument and vehicle development, etc.	$5,894,000
Scientific investigations in space; lunar and planetary exploration.	California Institute of Technology; NASw-6.	Research and development for propellants, communications, aerodynamics, chemistry, physics, heat, instrument and vehicle development, etc.	47,833,262
Space propulsion technology; space power technology.	California Institute of Technology; NASw-6.	Research and development for propellants, communications, aerodynamics, chemistry, physics, heat, instrument and vehicle development, etc.	515,000
Vehicle development; Saturn.	Douglas Aircraft, Inc.; NAS7-1.	Design, development, fabrication and testing of the Saturn S-IV stage vehicles.	8,961,000
	North American Aviation, Inc., Rocketdyne Division; NAS7-3.	Design, research, and development of NAA H-1 rocket engine.	5,324,262
	North American Aviation, Inc., Rocketdyne Division; NAS7-4.	Fabrication and production of H-1 rocket engine, and related spares and components.	597,153
Supporting activities tracking and data acquisition.	California Institute of Technology; NASw-6.	Research and development for propellants, communications, aerodynamics, chemistry, physics, heat, instrument and vehicle development, etc.	6,570,000
Support of JPL research.	NASw-6		2,285,000
Spacecraft technology (JPL).	NASw-6		2,560,000
June 2 (JPL)	NASw-6		303,612

ACTIVITY: MARSHALL SPACE FLIGHT CENTER

Program	Contractor and contract number	Purpose	Approximate obligations
Advanced research programs; support of NASA plant.	Chrysler Corp.; NAS8-6	Engineering services for Saturn, Mercury, and Juno programs.	$27,743
	Watland, Inc.; NAS-8-16.	Microfilming and operation of facilities in technical documentation.	304,200
	Hayes Aircraft Corp.; NAS8-18.	Engineering, fabrication, and other related services.	12,581
	Brown Engineering Co.; NAS8-20.	Engineering, fabrication, and other related services.	469,095
	General Electric Co.; NAS8-35.	General computing services	810,000
	Modern Machinery Associates, Inc.; NAS8-96.	1 machine, milling, profile and contour, 3 axis, tape controlled.	169,975
	Linde Co.; NAS8-255	Liquid oxygen and liquid nitrogen	276,976
	Chrysler Corp., Missile Division; NAS8-1504.	Services for tactical ground-support equipment used in firings of the tactical Jupiter weapons system at Cape Canaveral.	141,711
	Air Force Missile Test Center; H-1906.	Maintenance on LOD facilities at AMR.	323,450
	Army Ordnance Missile Command; H-3626.	Miscellaneous stock items procured by Redstone Arsenal for Marshall.	860,000
	Air Research and Development Command; H-3653.	Propellants for 17.5K engine	715,000

See footnotes at end of table.

R and D Contracts or Amendments Thereto of $100,000 and Over Shown by Program [1]—Continued

ACTIVITY: MARSHALL SPACE FLIGHT CENTER—Continued

Program	Contractor and contract number	Purpose	Approximate obligations
Advanced research programs; support of NASA plant.	Army Ordnance Missile Command; H-6702.	General maintenance services; water, security, transportation, electricity, sewage.	$404,504
	Army Ordnance Missile Command; H-6707.	General services; pictorial, closed TV circuit, airstrip post engineer field and shop, electronic equipment, carpenter and sheet metal shop, and custodial.	247,539
	Air Force Missile Test Center; H-6709.	Modify missile assembly building for Mace program.	101,000
	Army Ordnance Missile Command; H-9173.	Repair of electronic equipment, gage calibration, transportation, and vehicle maintenance.	171,725
	Air Research and Development Command; H-9174.	AFBMD/BMC support of the NASA Agena B program.	266,000
	Army Ordnance Missile Command; H-9189.	Distribution and maintenance electricity, water, steam, sewage disposal.	459,586
	Army Ordnance Missile Command; H-12277.	Digital mission	420,227
	Army Ordnance Missile Command; H-12294.	Custodial services, vehicle maintenance, operation and maintenance closed-circuit TV.	1,483,513
Scientific investigations in space; scientific satellites.	Chrysler Corp.; NAS8-6	Engineering services for Saturn, Mercury, Juno programs.	336,933
	Hayes Aircraft Corp.; NAS8-18.	Engineering, fabrication, and other related services.	60,792
	Brown Engineering Co.; NAS8-20.	Engineering, fabrication, and other related services.	603,523
Manned space flight	Chrysler Corp.; NAS8-6	Engineering services for Saturn, Mercury, and Juno programs.	411,238
	Hayes Aircraft Corp.; NAS8-18.	Engineering, fabrication, and other related services.	140
	Brown Engineering Co.; NAS8-20.	Engineering, fabrication, and other related services.	112,835
	Redstone Machine & Tool Corp.; NAS8-21.	Fabrication services related to Saturn and Mercury programs.	14,201
	SpaceManufacturing Co.; NAS8-23.	Fabrication and assembly work and related services.	9,565
Vehicle systems technology.	Chrysler Corp.; NAS8-6	Engineering services for Saturn, Mercury, and Juno programs.	31,033
	The Martin Co.; NAS8-801.	Study of operational modes of Saturn C2 system.	114,815
	Minneapolis - Honeywell Regulator Co., Aeronautical Division; NAS8-821.	Development of a ceramic gas bearing spin motor and gimbal assembly.	143,439
	Chance Vought Corp., Vought Astronautics Division; NAS8-853.	Study of orbital launch operations	112,156
	Lockheed Aircraft Corp., Missile and Space Division; NAS8-864.	Early rendezvous demonstration study.	100,000
	Packard Bell Electronics Corp.; NAS8-876.	Automatic checkout system for S-1 vehicle Saturn.	247,955

See footnotes at end of table.

R and D Contracts or Amendments Thereto of $100,000 and Over Shown by Program[1]—Continued

ACTIVITY: MARSHALL SPACE FLIGHT CENTER—Continued

Program	Contractor and contract number	Purpose	Approximate obligations
Vehicle systems technology.	General Electric Co.; NAS8-881.	Development of a cryogenic accelerometer.	$119,613
	General Dynamics Corp., Convair Astronautics; NAS8-898.	Conceptual design studies of a vehicle in the 6 to 12 million-lb.-thrust class.	130,017
	North American Aviation, Inc., Space and Information Systems Division; NAS8-899.	Conceptual design studies of a vehicle in the 6 to 12 million-lb.-thrust class.	160,041
	Lockheed Aircraft Corp.; NAS8-900.	Conceptual design studies of a vehicle in the 6 to 12 million-lb.-thrust class.	136,743
	General Dynamics Corp., Convair Astronautics; NAS8-1513.	Conceptual design studies of a vehicle in the 2 to 3 million-lb.-thrust class.	115,565
	The Martin Co.; NAS8-1515.	Conceptual design studies of a vehicle in the 2 to 3 million-lb.-thrust class.	163,040
Space propulsion technology; liquid rockets.	North American Aviation, Inc., Rocketdyne Division; NAS8-1522.	Stability rating program for large rocket-engine systems.	133,614
Space power technology	Hughes Aircraft Co., Hughes Research Laboratories; NAS5-517.	Design, fabrication, and testing of a cesium ion rocket engine.	811,201
Vehicle development; Centaur.	Air Research and Development Command; NAS8-14.	Procurement of XLR-115 engine	2,300,000
	Air Research and Development Command; NAS8-515.	Design, development, and fabrication of Centaur upper stage vehicles and associated equipment.	18,760,000
	Army Ordnance Missile Command; H-6698.	Provide support to enable damp ship to participate in 2 or more Agena-Ranger missions.	133,652
	Air Research and Development Command; H-6705.	Procurement of 2 500-lb. PODS plus electric power, telemetry, and payload integration.	110,000
	Air Research and Development Command; H-6706.	10 Atlas boosters required for the Centaur program.	3,000,000
	Air Research and Development Command; H-6708.	Support the Agena B program	3,182,000
Vehicle development; Saturn.	Chrysler Corp.; NAS8-6	Engineering services for Saturn, Mercury, and Juno programs.	6,368,413
	Hayes Aircraft Corp.; NAS8-18.	Engineering, fabrication, and other related services.	3,786,160
	Brown Engineering Co.; NAS8-20.	Engineering, fabrication, and other related services.	1,753,903
	Redstone Machine & Tool Corp.; NAS8-21.	Fabrication services related to Saturn and Mercury programs.	311,766
	Lockheed Aircraft Corp.; NAS8-22.	Engineering, fabrication, and related services.	734,472
	Spaco Manufacturing Co	Fabrication and assembly work and related services.	362,747
	Progressive Welder & Machine Co.; NAS8-25.	Engineering, design, and fabrication for tooling manufacture.	265,571
	Avco Corp.; NAS8-27	Engineering and fabrication for special tooling and vehicle components for Saturn.	238,371

See footnotes at end of table.

R and D Contracts or Amendments Thereto of $100,000 and Over Shown by Program[1]—Continued

ACTIVITY: MARSHALL SPACE FLIGHT CENTER—Continued

Program	Contractor and contract number	Purpose	Approximate obligations
Vehicle development; Saturn.	Electronic Associates, Inc.; NAS8-38.	Precision analog computing system, type 231R.	$174,460
	Air Research and Development Command; NAS8-73.	Design, manufacture of components and ground support equipment for Agena program.	10,927,700
	General Precision, Inc., Librascope Division; NAS8-511.	Prototype digital computor with sigmator.	127,647
	Texas Instruments, Inc.; NAS8-593.	150-amplifiers	130,500
	Sperry Rand Corp., Sperry Farragut Co.; NAS8-812.	Engineering and fabrication services and/or manufacturing control and instrumentation.	413,363
	Consolidated Systems Corp.; NAS8-817.	High-speed digital processing system	141,290
	North American Aviation Inc.; NAS8-829.	Interstage fairings	229,520
	Radio Corp. of America, West Missile and Surface Radar Division; NAS8-870.	Development of a Saturn ground computer complex.	316,611
	International Business Machines Corp., Federal Systems Division; NAS8-872.	Test equipment for IBM ASC-15 equipment.	160,000
	Chrysler Corp.; NAS8-868.	Jupiter aft sections and 8 items of components parts.	117,498
	A. L. Mechling Barge Line, Inc.; NAS8-882.	Towage services, Government barge *Palaemon*.	176,090
	The Ryan Aeronautical Co.; NAS8-1501.	Study of paraglider recovery system for Saturn booster.	145,828
	North American Aviation, Inc., Space and Information Systems Division; NAS8-1502.	Study of paraglider recovery system for Saturn vehicle.	170,000
	North American Aviation, Inc., Space and Informations Systems Division; NAS8-1514.	Conceptual design studies of a vehicle in the 2 to 3 million-lb.-thrust class.	148,487
	Lockheed Aircraft Corp., Georgia Division; NAS8-1557.	Saturn booster pressure and functional checkout equipment.	335,000
	Cadillac Gage Co.; NAS8-1564.	Hydraulic package assemblies and components.	129,600
	Air Research and Development Command; H-3653.	Propellant for 17.5K engine	350,000
	Air Research and Development Command; H-6714	Wind-tunnel test time for Saturn base-heating tests.	187,200
	Air Research and Development Command; H-12270.	Studies and preliminary design of the S-V stage for the Saturn C-1 vehicle.	150,000
	Air Research and Development Command; H-12275	Establish base region heat fluxes due to convection and radiative heat transfer and flow phenomena.	120,000

See footnotes at end of table.

R and D Contracts or Amendments Thereto of $100,000 and Over Shown by Program [1]—Continued

ACTIVITY: SPACE TASK GROUP

Program	Contractor and contract number	Purpose	Approximate obligations
Manned space flight	McDonnell Aircraft Corp. NAS5-59.	Project Mercury capsule, spare parts, ground-support equipment, training aids, technical data, and other matters related thereto.	$29,223,912
	Federal Electric Corp., ITT Federal Services Division; NAS5-305.	Capsule telemetry services	196,000
	Armco Drainage & Metal Products, Inc., Dixie Division; NAS5-306.	NASA engineering and storage annex, concrete work, and building shells.	158,417
	Philco Corp., Philco Tech. Rep. Division; NAS5-307.	Capsule system monitor services	410,000
	Collins Radio Co.; NAS9-107.	Amateur-type single-sideband radio equipment.	140,471
	Air Force Ballistic Missile Division; HS-36.	Atlas booster program for Project Mercury.	10,000,000
	Air Force Missile Test Center; S-3652 G.	Logistic support from AFMTC for Project Mercury.	487,000
	Lindsey Air Station, USAF in Europe; T-1557 G.	Services in support of Project Mercury recovery operations.	143,000
	International Business Machine Corp.; T-1612.	Rental of 1 IBM 7090 computer	544,500

[1] Includes all R and D contracts of $100,000 or more, or amendments thereto totaling $100,000 negotiated during the indicated period. Certain actions were funded from more than one program; therefore, the obligations shown for the individual programs may be less than $100,000.

[2] Period of Apr. 1, 1961, through June 30, 1961, will be reported in the "Sixth Semiannual Report to Congress."

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